JOURNAL OF DAIRY SCIENCE

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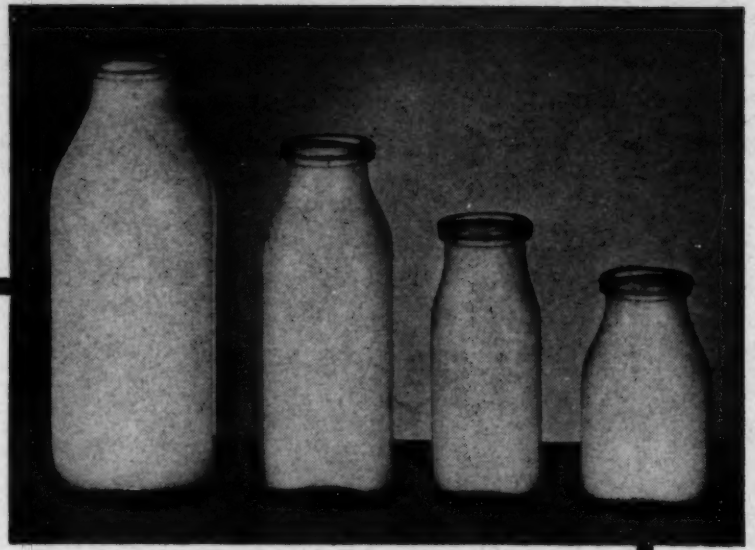

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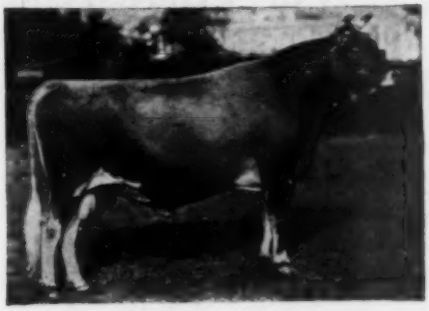

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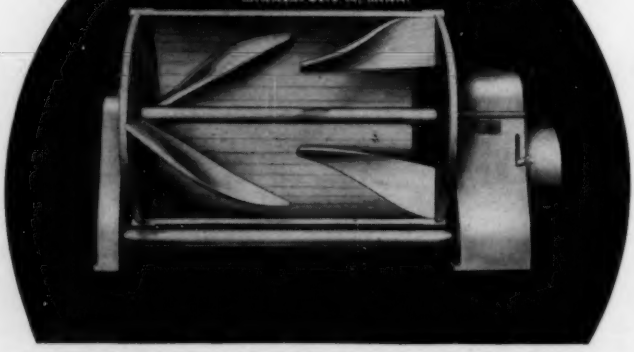

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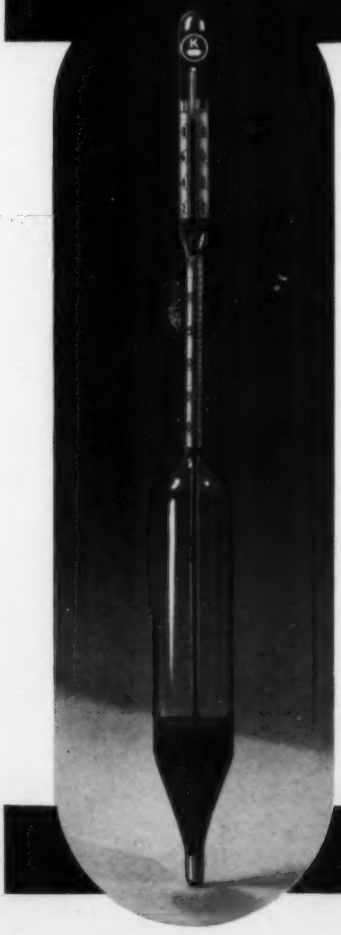

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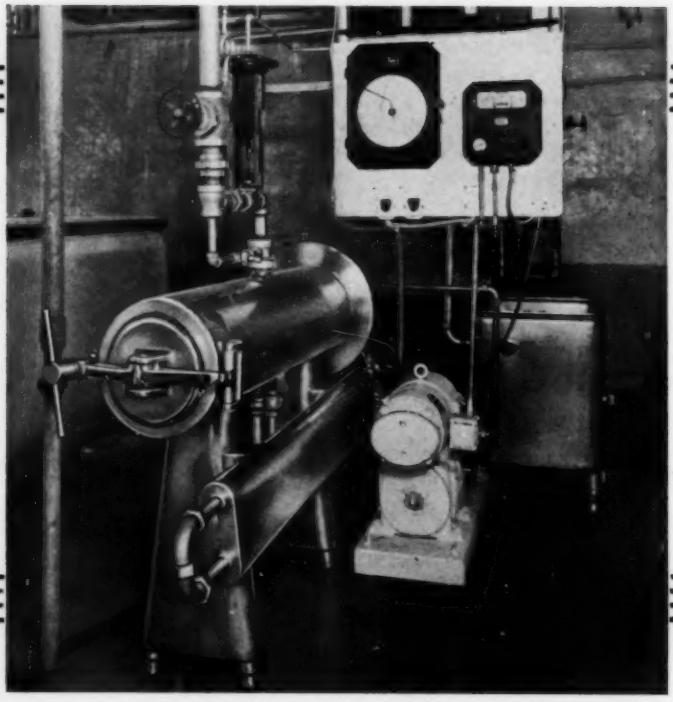

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JOURNAL OF DAIRY SCIENCE

VOLUME XXVIII SEPTEMBER, 1945 NUMBER 9

SUBSTANCES ADSORBED ON THE FAT GLOBULES IN CREAM AND THEIR RELATION TO CHURNING. VI. RELATION OF THE HIGH-MELTING TRIGLYCERIDE FRACTION TO BUTTERFAT AND THE "MEMBRANE"[1]

ROBERT JENNESS AND L. S. PALMER[2]

University of Minnesota, St. Paul, Minnesota

In an earlier paper Palmer and Wiese (5) reported the isolation of a high-melting triglyceride fraction from "membrane" preparations from washed cream. Later work (4, 6) showed that protein and phospholipides together accounted for only 40 to 65 per cent of supercentrifuged "membrane" preparations. The remainder was phosphorus-free lipide which undoubtedly included the high-melting fraction. This paper reports an attempt to clarify the origin and nature of this fraction.

METHODS

The high-melting glyceride fraction was prepared from washed cream buttermilk extracts, from washed cream butter serum extracts, and from filtered butterfat by crystallization from ethanol solution at 24–25° C. Details of the various crystallization experiments are described later.

Iodine numbers were determined by Yasuda's (8) modification of the Rosemund-Kuhnhenn (7) method. Saponification numbers were determined on 0.2- to 0.5-gram portions of this material using 5 or 10 ml. of the alcoholic potassium hydroxide solution recommended by the A.O.A.C. (1) and vigorous boiling for one hour. Since titration with N/2 hydrochloric acid yielded too small titer differences, N/10 acid was substituted. Attention is called to the necessity, when N/10 acid is used, of adding more alcohol (20 ml. suffices), either before or after saponification, to insure that the ratio of water to alcohol does not become so high during titration that fat acids are precipitated.

Received for publication March 17, 1945.

[1] Paper No. 2221, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota. The data presented herein are taken from a thesis submitted by Robert Jenness to the Graduate School of the University of Minnesota, June 1944, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

[2] Deceased March 8, 1944.

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Phosphorus was determined by the Fiske-Subbarow (2) method after ashing the sample with magnesium nitrate.

RESULTS

The preceding paper in this series (4) reported studies of "membrane" materials in creams from cows fed in successive periods (a) a ration containing large proportions of whole cottonseed and cottonseed oil and (b) a standard herd ration. The samples afforded an opportunity to ascertain whether the amount and characteristics of the high-melting glyceride observed by Palmer and Wiese (5) are dependent on the characteristics of butterfat. To this end, the portion of alcohol-ether extract of those samples, remaining after removal of aliquots for phosphorus analysis, was evaporated nearly to dryness and dissolved in 100 ml. of warm absolute ethanol. The copious white precipitate that separated upon standing overnight at 24–25° C. was filtered off, dried in vacuum and weighed. Since it was of interest to compare the materials thus obtained from buttermilk and butter serum with the fraction of butterfat itself insoluble under like conditions, 5 per cent ethanol solutions of 3 butterfats in each group were prepared, allowed to stand at 24–25° C., and the insoluble fraction filtered off.

The yields and some of the properties of the insoluble material from each of the three sources are shown in tables 1 and 2. The percentage of ethanol-insoluble lipides in buttermilk extract is of the same order of magnitude as that in butterfat itself, but the yield from butter serum extract is much greater. Return of the cows to the herd ration reduced the quantity of this

TABLE 1

Yields of ethanol-insoluble fractions of butterfat, buttermilk, and butter serum

Sample	Buttermilk extract*		Butter serum extract*		Butterfat	
	Concentration	Insoluble fraction	Concentration	Insoluble fraction	Concentration	Insoluble fraction
	gms./100 ml.	%	*gms./100 ml.*	%	*gms./100 ml.*	%
Cottonseed ration						
11	2.5	21.6	0.8	31.9	.....	.....
12	4.3	18.1	1.1	41.4	5.0	13.6
13	2.4	21.1	0.6	50.0	5.0	18.3
15	5.1	20.0	1.3	37.3	5.0	12.3
Herd ration						
16	10.3	21.0	3.5	43.8	.....	.....
17	6.9	11.3	0.6	20.1	5.0	8.1
18	6.6	12.3	.....	.....	.....	.....
19	7.3	11.1	0.9	38.1	5.0	8.8
20	11.0	23.3	2.3	35.4	.....	.....
21	4.7	9.6	2.1	41.5	5.0	9.4

* Calculated phosphorus-free extract.

TABLE 2

Properties of ethanol-insoluble fractions of butterfat, buttermilk, and butter serum

Sample	Insoluble fraction of						Original butterfat	
	Buttermilk extract		Butter serum extract		Butterfat			
	Sap. No.	Phosphorus	Sap. No.	Phosphorus	Sap. No.	I—No.	Sap. No.	I—No.
		%		%				
12	191.0	.....	.....	.....	.....	.....	218.2	40.9
13	196.1	.....	.....	.....	201.1	18.80	214.9	38.9
15	195.6	.....	.....	.....	.....	.....	219.9	39.6
17	198.7	0.117	195.8	0.240	.....	.....	226.0	36.2
19	208. 5	0.031	200.4	0.052	202.6	11.65	226.3	38.8
21	212.8	0.038	205.1	0.037	.....	.....	229.7	31.6

fraction obtainable from butterfat and with two exceptions reduced that from buttermilk also. In the two exceptional cases the buttermilk extract was larger than usual (indicating less exhaustive churning), and, as will be shown, the percentage of the ethanol-insoluble fraction in a mixed fat, like butterfat, depends upon the total concentration of fat in solution. Except in one case, for which no explanation is evident, the high percentage of insoluble lipide in the butter serum extract was not reduced by the return to herd ration.

TABLE 3

Yield and properties of high melting triglyceride fractions once crystallized from ethanol

Sample	Concentration	Yield insol. fraction	Iodine number		Phosphorus in insol. fraction
			Butterfat	Insol. fraction	
	gms./100 ml.	%			%
27 Butterfat	1.0	6.9	26.7	9.2	.....
	5.1	13.8	.....	11.8	.....
28 Butterfat	1.0	5.5	39.7	18.8	.....
	5.1	19.2	.....	26.0	.....
38 Butterfat	3.1	9.0	30.8	15.2	.....
	3.9	8.9	.....	13.2	.....
39 Butterfat	3.0	10.0	33.6	16.0	.....
	4.0	10.8	.....	15.0	.....
29 Butterfat	3.2	7.0	.....	11.5	.....
	6.3	10.7	.....	18.6	.....
Buttermilk extract*	3.2	8.9	.....	13.1	0.20
Butter-serum extract*	6.8	26.0	.....	13.5	0.16
31 Butterfat	1.1	4.4	.....	.....	.....
	2.1	6.9	.....	10.3	.....
Buttermilk extract*	0.8	6.0	.....	14.8	0.82
Butter-serum extract*	1.9	32.1	.....	7.0	0.09

* Concentrations and yields are based on calculated phosphorus-free extract.

Saponification numbers of the insoluble lipide were of the same order of magnitude irrespective of whether it was obtained from buttermilk, butter serum, or butterfat.

Data obtained in certain other samples are reported in table 3. It appears that the iodine numbers of the insoluble fraction are relatively constant regardless of its source.

The phosphorus contents of the ethanol-insoluble fraction of buttermilk and butter-serum extracts (tables 2 and 3) were sufficiently high to suggest the desirability of a second crystallization. Accordingly a study was made of the materials obtainable by two crystallizations from several samples.

TABLE 4

Yield and properties of high-melting triglyceride fractions twice crystallized from ethanol

Sample	Once crystallized from ethanol		Twice crystallized from ethanol						
			Conc.	Insoluble fraction					
	Conc.	Insol.		Yield*	I—No.	Sap. No.	Melt. Pt.	Solid. Pt.	Phosphorus
	gms./ 100 ml.	%	*gms./ 100 ml.*	%			°C.	°C.	%
Composite†	.....	.....	.....	.....	7.1	198.8	.....	.....	0.048
Buttermilk extract‡	.....	.....	.....	.....	5.4	202.3	.....	.....	0.068
Sample 44									
Butterfat	1.0	2.3	.....	.....					
	2.5	4.0	2.5	3.5					
	5.0	6.8	2.5	5.1	6.7	204.0	52.0	42.0	.....
	7.5	7.2	2.5	4.9					
Buttermilk extract§	6.6	5.9	0.8	4.1	5.9	201.2	53.0	42.0	0.028
Butter-serum extract§	5.0	45.3	2.1	37.4	5.0	202.2	52.5	.....	0.057

* Per cent of original lipide.

† Composite of several samples of once crystallized ethanol-insoluble lipide from buttermilk, and butter serum.

‡ Once crystallized ethanol-insoluble lipide from buttermilk extract.

§ Calculated phosphorus-free extract.

The results, shown in table 4, indicate that a material of rather constant properties can be secured from buttermilk, butter serum, or butterfat by two crystallizations from ethanol. Attention is called to the influence of concentration of lipide on the yield of insoluble fraction upon a single crystallization. Consequently, comparisons of yields and properties are valid only if the original solutions were of approximately the same concentration.

The melting points of our preparations are similar to those of the high-melting glyceride reported by Palmer and Wiese (5), but the saponification

numbers are slightly higher. It is interesting to note that our preparations possess iodine numbers and melting points similar to those found by Henderson and Jack (3) in a butterfat fraction crystallized from Skellysolve at −7° C. However, their fraction had a saponification number of 213.4, indicating a less complete segregation of the glycerides containing long-chain fat acids than in our preparations.

The presence of the ethanol-insoluble fraction in buttermilk may be explained merely by assuming that butterfat is present as unchurned fat globules or as butter granules. Such an assumption does not explain the high proportion of this fraction in butter serum, the reason for which was next sought.

It was considered that possibly a fraction of butterfat might have crystallized and been centrifuged down to the serum layer when the butter serum was centrifuged. This hypothesis was impugned by the finding that concentrated washed cream buttermilk could not be enriched in the ethanol-insoluble fraction by stirring butterfat into it, and holding and centrifuging in the same manner as for butter serum.

The hypothesis of Rimpila and Palmer (6), that the high-melting fraction appears in "membrane" preparations because of a special affinity of the "membrane" for the higher melting molecules of butterfat, was next considered. It was given some substantiation by the finding that ether extracted 61 per cent of the ethanol-soluble lipide but only 38 per cent of the ethanol-insoluble fraction from a sample of unconcentrated butter serum.[3] The problem is still far from settled, however, and will require further study.

DISCUSSION

The discovery that a high-melting, ethanol-insoluble triglyceride, similar to that described by Palmer and Wiese (5), is present in much higher concentration in butter serum than in buttermilk, poses the interesting question of its origin and relation to the "membrane." The results reported herein appear to be best explained by the hypothesis advanced by Rimpila and Palmer (6) that a special affinity exists between "membrane" and high-melting fat molecules.

The disruption of the "membrane" complex by churning has been discussed in a recent paper (4). Apparently this disruption is such that some of the "linkages" between protein and phospholipide as well as some of those between phospholipide and fat are broken. The buttermilk, then, contains a complex of protein and phospholipide relatively richer in the former than was the original "membrane." It also contains butterfat as unchurned fat globules and as butter granules, and upon appropriate treatment a portion of this butterfat appears as a high-melting fraction, very similar to a fraction that can be obtained from melted butterfat upon like treatment.

[3] Incidentally, the ether extracted only 10 per cent of the lipide phosphorus in the sample.

The butter serum is left with a protein-phospholipide complex relatively richer in the latter than was the original "membrane." Upon melting the butter, the phospholipide continues to cling to certain of the higher melting molecules with the result that they are pulled into the serum. The butter serum extract, then, contains a higher proportion of the high-melting fraction than does the melted butterfat.

SUMMARY

High-melting triglyceride fractions of rather similar properties were obtained from butterfat, washed-cream buttermilk extracts, and washed-cream butter-serum extracts by crystallization from ethanol.

Fractions twice crystallized from ethanol had iodine numbers of 5.0–7.1, saponification numbers of 198.8–204.0 and melting points of 52–53° C.

Yields of this material from buttermilk extract were similar to those from butterfat solutions of like concentration but the yield from butter-serum extracts was invariably much greater. The significance of this finding has been discussed.

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PREDICTABILITY OF BREEDING EFFICIENCY IN DAIRY CATTLE FROM THEIR PREVIOUS CONCEPTION RATE AND FROM THEIR HEREDITY[1]

GEORGE W. TRIMBERGER[2] AND H. P. DAVIS
University of Nebraska

The repeatability of a good or poor individual breeding record in dairy cattle from year to year and the hereditability of high or low breeding efficiency for individuals and families is a question that receives considerable discussion among dairymen. Since artificial insemination has come into wide use, the variations in fertility for dairy bulls have been recognized and studied more than the fluctuations in the breeding efficiency of dairy females.

Käb (1) made an analysis of the fertility of the daughters from twenty-two bulls. He believed the variations that existed pointed to a genetic factor. When several generations were considered, he found thirty-five families with high and eleven families with low fertility.

Spielman and Jones (4) determined the reproductive efficiency for groups of dairy females descended from different foundation cows. They used as a measure of reproductive efficiency a numerical expression based on the assumption that to be a hundred per cent efficient, a heifer should be bred at a certain age depending upon the breed, and that she should drop a calf every twelve months thereafter. They concluded that a marked difference in reproductive efficiency existed between various cow groups. The methods used to measure breeding efficiency in dairy cattle by Spielman and Jones is not applicable to the records in the present study because not all cow families and breeds were bred at the same time after calving since high and persistent producing individuals and cow families were allowed a longer interval after calving before they were rebred.

Data on breeding efficiency of cow families reported by Seath, Staples, and Neasham (3) revealed wide variations which ranged from a low of 40.6 per cent to a high of 92.3 per cent and averaged 63.3 per cent based on services resulting in conceptions. They believed that breeding efficiency was inherited and that culling and selection should give consideration to this factor.

This report is based on an analysis of the breeding records for the females of the Ayrshire, Guernsey, Jersey, and Holstein breeds by artificial insemination over an eight-year period in the University of Nebraska dairy

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[1] Published with the approval of the Director as Paper No. 375, Journal Series, Nebraska Agricultural Experiment Station.

[2] Now at Cornell University, Ithaca, New York.

herd. Every female of breeding age in the herd had been artificially inseminated from 1936 to 1944. By this method of breeding, observations were made and information is available on quality of semen and fertility of the bulls far in excess of that available with natural service. In general, a sire was not retained in service if his fertility dropped below the fifty per cent level for conceptions from the first service as determined by actual pregnancy examinations per rectum two months after service. On the above basis from a total of forty-four bulls used for service, there were thirty-five individuals with a satisfactory breeding record and nine with a poor record. Among the unsatisfactory group, four bulls had trichomoniasis, three had a high percentage of abnormal sperm cells, one had a low percentage of motile spermatozoa, and one bull had extremely low conception rate in the females to which he was bred although his semen appeared to be of high quality. He apparently was free from infection since a high percentage of the females conceived when they were bred to another bull three weeks later. It should be mentioned that the nine bulls with the poor breeding records exerted only a very small influence on the final results, for only a limited number of females were bred to these individuals before they were taken out of service. Females bred to these nine bulls would include less than five per cent of the total number bred during the eight-year period on which this report is based. The objective was to keep the breeding efficiency high, and a sire with low fertility was kept in service only long enough to prove him a poor breeder. This was essential because several investigations were conducted on breeding efficiency in the females relative to the conception rate from services at various stages of estrus (6) and at various intervals before and after ovulation (5).

The general health of the herd was good and the entire herd was free from Bang's disease. The limited number of females which became infected after they were bred to the four bulls with trichomoniasis usually recovered satisfactorily after they were given a rest from sexual activity for two months and often veterinary treatment was given during this period. Females with retained corpora lutea were usually brought into heat by manual manipulation of the ovaries but occasionally a hormone injection was made to accomplish the same purpose. It was a standard procedure to allow three services to a female and if conception did not take place then the individual was given veterinary treatment. If cystic ovaries were found at this time, they were treated by massaging them and sometimes by the injection of hormones. Females with an infection in the genital organs were given a sexual rest period and veterinary treatment. Another successful treatment used for difficult breeders was to withhold service at the time of estrus and place them on a new cycle by removing the corpus luteum from the ovary about eight to ten days after the previous estrus period. Service during estrus which followed treatment, or during the next estrus if the female returned, often resulted in conception.

The breeding efficiency of cows and heifers by artificial insemination in the University of Nebraska dairy herd from 1936 to 1944 is given in table 1. The number of females bred, number of sterile females, and percentage of conception at various services is given by breeds and divided into groups for virgin heifers and cows. Among 221 virgin heifers bred, 127 or 57.47 per cent conceived to the first service; 46 or 20.81 per cent to the second; 15 or 6.79 per cent to the third service; 13 or 5.88 per cent to the fourth; 8 or 3.62 per cent required five or more services; and 12 or 5.43 per cent were sterile. This gave the virgin heifers a requirement of 1.74 services per conception to the fertile heifers and 2.03 services per conception when all services are considered.

The cows for all breeds totalled 418 on the basis of cow years when each year a female was bred was considered one individual. In this group 258 or 61.72 per cent conceived to the first service; 71 or 16.99 per cent to the second; 35 or 8.37 per cent to the third service; 14 or 3.35 per cent to the fourth; 17 or 4.07 per cent required five or more services; and 23 or 5.50 per cent of the cows were sterile, after a total of 137 services. This indicates 1.68 services per conception to the fertile cows, and 1.92 services per conception when the services to the sterile cows are included. The difference in the rate of conception for virgin heifers and cows was not large enough to be significant. In a previous research Morgan and Davis (2) reported for natural service from 1896 to 1934 in this same herd. They found that 537 virgin heifers required 2.52 services per conception as compared to 2.21 services per conception for 2,090 females of all ages.

When virgin heifers and cows were combined for all breeds, a total of 639 were bred and 385 or 60.25 per cent conceived to the first service; 117 or 18.31 per cent to the second; 50 or 7.82 per cent to the third service; 27 or 4.23 per cent to the fourth; 25 or 3.91 per cent with five or more services; and 35 or 5.48 per cent of the females were sterile, after a total of 222 services. These indicate an average of 1.70 services per conception to the fertile females and 1.95 services per conception when the services to the sterile females are included. As stated previously, these figures are based on results from breeding by artificial insemination and the major portion of the inseminations were made by the senior author of this paper. It should be mentioned that for females of average value, the sterile individuals probably would not be allowed as many services as were the females in this case before they were dropped from the herd.

In table 2 the breeding efficiency is given by months to determine whether there is any significant monthly difference. When the females were listed under the month during which the first service was given, it was found that the highest number of services per conception was required during the summer and late summer months. The high number of 2.24 services per conception during August was highly significant. Morgan and Davis (2) pub-

TABLE 1

Breeding efficiency of cows and heifers by artificial insemination in the University of Nebraska dairy herd from 1936 1944

Age	Breed	Females bred	Conceptions at the various services										Sterile* females		Service to sterile females	Services per conception	
			First		Second		Third		Fourth		Five or more					All females	Fertile females
		No.	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No	Per cent	No.	Per cent	No.	No.	No.
Virgin heifers	Ayrshire	45	24	53.33	13	28.89	3	6.67	3	6.67	1	2.22	1	2.22	11	1.96	1.75
	Guernsey	44	22	50.00	8	18.18	6	13.64	2	4.55	1	2.27	5	11.36	38	2.50	1.85
	Jersey	49	34	69.39	7	14.29	4	8.16	2	4.08	.....	.....	2	4.08	10	1.59	1.45
	Holstein	83	47	56.62	18	21.69	2	2.41	6	7.23	6	7.23	4	4.82	26	2.08	1.86
	All breeds	221	127	57.47	46	20.81 +	15	6.79	13	5.88	8	3.62	12	5.43	85	2.03	1.74
Cows	Ayrshire	93†	50	53.77	17	18.28	12	12.90	4	4.30	2	2.15	8	8.60	44	2.04	1.72
	Guernsey	77	47	61.04	18	23.37	3	3.90	2	2.60	4	5.19	3	3.90	23	1.94	1.70
	Jersey	93	71	76.34	8	8.60	4	4.30	3	3.23	3	3.23	4	4.30	22	1.62	1.45
	Holstein	155	90	58.06	28	18.07	16	10.32	5	3.23	8	5.16	8	5.16	48	2.02	1.80
	All breeds	418	258	61.72	71	16.99	35	8.37	14	3.35	17	4.07	23	5.50	137	1.92	1.68
Virgin heifers and cows	Ayrshire	138†	74	53.63	30	21.74	15	10.87	7	5.07	3	2.17	9	6.52	55	2.01	1.73
	Guernsey	121	69	57.03	26	21.48	9	7.44	4	3.31	5	4.13	8	6.61	61	2.13	1.74
	Jersey	142	105	73.95	15	10.56	8	5.63	5	3.52	3	2.11	6	4.23	32	1.61	1.45
	Holstein	238	137	57.57	46	19.33	18	7.56	11	4.62	14	5.88	12	5.04	74	2.04	1.82
	All breeds	639	385	60.25	117	18.31	50	7.82	27	4.23	25	3.91	35	5.48	222	1.95	1.70

* Females were considered sterile if they did not conceive with five or more services or if their reproductive organs were diseased after several services and the individual was given little chance for conception at time of slaughter.

† An individual is counted on the basis of cow years as one for each year bred and the same female may be included several times.

TABLE 2

Breeding efficiency by months obtained from artificial insemination for each breed over a period of eight years

	Month*																							
	January		February		March		April		May		June		July		August		September		October		November		December	
	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services	Females	Services
Ayrshire	9	20	18	27	15	25	9	17	21	31	8	16	9	18	5	14	7	14	13	22	12	13	3	6
Guernsey	16	25	7	12	17	29	11	17	13	21	7	9	5	14	5	10	4	9	10	26	10	16	8	10
Jersey	14	25	8	10	13	15	10	13	14	29	12	21	12	14	11	19	8	13	9	10	10	10	15	18
Holstein	17	28	24	38	29	48	31	57	19	37	16	26	15	32	12	31	14	22	15	28	18	37	16	27
Total	56	98	57	87	74	117	61	104	67	118	43	72	41	78	33	74	33	58	47	86	50	76	42	61
Services per conception	1.75		1.53		1.58		1.70		1.76		1.67		1.90		2.24†		1.76		1.83		1.52		1.45	

* An individual is listed under the month during which the first service was given.
† Highly significant.

lished an analysis of the breeding record for this same herd over a period of thirty-eight years from natural service. Their report stated that August with 2.78 and September with 2.85 services per conception were much higher than the other months of the year.

During this eight-year period there were forty-seven cases of retained placenta among forty-one different females. An analysis of these forty-seven cases showed that three were sold with metritis, two were sold as sterile after ten and five services each, and five were sold as breeders before they were rebred but their reproductive systems upon examination appeared to be normal. Among the thirty-seven in which conception occurred, 22 or 59.46 per cent conceived to the first service; 7 at the second; 4 at the third; one at the fourth; and 3 at the fifth service. This gave them an average of 1.81 services per conception, which is very close to the average for all females.

TABLE 3

A comparison between number of services required for the first conception in virgin heifers and number required for following conceptions

	Service at which conception occurred in virgin heifers				
	First	Second	Third	Fourth	Fifth or more
Number of individuals	79	27	8	14	5
Total number of services for second conception	131	44	15	25	8
Services per conception for second calf	1.66	1.63	1.88	1.79	1.60
Services per conception for all conceptions after first calving throughout lifetime of individuals	1.70	1.60	1.42	2.11	1.50

Calculations were made relative to the predictability of breeding efficiency from the previous breeding record of an individual. In table 3 a comparison is made as to the number of services required for the first conception in virgin heifers, the number required for the subsequent conception, and the number required for a lifetime average after the first calving. The virgin heifers were grouped according to whether conception occurred at the first, second, third, fourth, and fifth or more services. The results of 1.66, 1.63, 1.88, 1.79, and 1.60 services per conception listed in order to correspond to the grouping above indicate that it is not possible to predict the rate of conception for the second pregnancy from the number of services required for conception in virgin heifers. When this is calculated on the basis of services per conception throughout the lifetime of the individuals, the results of 1.70, 1.60, 1.42, 2.11, and 1.50 services per conception were obtained. Thus the number of services required per conception in virgin heifers has no value in predicting the number required for the subsequent conception

TABLE 4

Number of services required for one conception in cows compared to the number required for the next pregnancy

	Service at which conception occurred for the previous pregnancy				
	First	Second	Third	Fourth	Fifth or more
Number of cows for comparison of two successive pregnancies	133	38	12	7	9
Services per conception for following pregnancy	1.65	2.00	1.92	1.43	1.33

or the average number of services required per conception throughout the life of the individual.

In table 4 a comparison is made as to the number of services required for conception in cows for one year and the repeatability of these for the number required during the following year. Groupings were made as to whether conception occurred the previous year from the first, second, third, fourth, and fifth or more services. The services required per conception during the following year for the various groupings listed above were 1.65, 2.00, 1.92, 1.43, and 1.33. This indicates that there is no predictability from one year to another as to the breeding efficiency for an individual. Observations in artificial breeding associations show that the same is true for herds from one year to another as a herd may have a good record one year and a poor one the next, or a herd with a poor breeding record may have a good one the next.

Table 5 shows that it is not possible to predict the conception rate in virgin heifers from the breeding efficiency of their dams at the time they were virgin heifers. In table 6 this daughter-dam comparison is made for the average number of services for all conceptions throughout the lifetime of the individuals, and the results indicate that it is not possible to predict the conception rate in daughters from the breeding records of their dams.

The previous breeding records for the cows which were sold as sterile were checked to determine whether their breeding histories had given any

TABLE 5

Daughter-dam comparison on services per conception for first pregnancy in heifers

	Service at which conception occurred in the dams for their first pregnancy				
	First	Second	Third	Fourth	Fifth or more
Number of daughter-dam comparisons	46	18	2	4	1
Services per conception for first pregnancy in daughters	1.85	2.06	2.00	1.50	2.00

TABLE 6

Daughter-dam comparison for all conceptions throughout lifetime of individuals

	Class interval for services required per conception by the dams for lifetime average					
	1.00–1.49	1.50–1.99	2.00–2.99	3.00–3.99	4.00–4.99	5.00 & over
Number of daughter-dam comparisons	48	16	20	4	2	2
Actual lifetime average number services per conception for dams	1.08	1.61	2.18	3.23	4.25	6.00
Actual lifetime average number services per conception for daughters	1.72	1.55	1.91	1.33	1.36	2.65

indication that sterility would follow. The twenty-three cows sold as sterile previously had a total of forty-five conceptions from eighty-three services. This gives them a requirement of 1.84 services per conception which is very close to the average of 1.70 services per conception to the fertile cows, and from this it can be concluded that the previous record did not indicate that sterility would occur in these cows.

The breeding efficiency for the various cow families in the University of Nebraska dairy herd was tabulated in table 7. Any cow family with five or more individuals was included. The services per conception for the

TABLE 7

Breeding efficiency for the cow families in the University of Nebraska dairy herd

Cow family	Breed	Individuals	Conceptions	Sterile females	Service to fertile females	Service per conception
		No.	*No.*	*No.*	*No.*	*No.*
A	Ayrshire	9	16	1	27	1.69
B	Ayrshire	16	42	6	82	1.95
C	Ayrshire	7	16	0	28	1.75
S	Ayrshire	13	38	0	57	1.50
B	Guernsey	5	12	0	35	2.92*
C	Guernsey	10	19	1	29	1.53
F	Guernsey	8	20	1	37	1.85
G	Guernsey	5	10	1	17	1.70
N	Guernsey	13	24	3	35	1.46
A	Holstein	10	20	3	34	1.70
E	Holstein	17	26	1	51	1.96
G	Holstein	8	17	2	29	1.71
K	Holstein	17	33	1	61	1.85
L	Holstein	7	21	1	31	1.48
P	Holstein	12	32	1	60	1.88
Q	Holstein	27	48	2	93	1.94
M	Jersey	9	25	1	43	1.72
R	Jersey	16	32	1	39	1.22*
S	Jersey	8	12	2	12	1.00*
V	Jersey	4	16	0	22	1.38
Totals and average		221	479	28	822	1.72

* Highly significant.

various families are very uniform, but there is one group which had a highly significant low conception rate and two cow families with fertility so good that it was highly significant. The cow family of low fertility required 2.92 services per conception and was the only group that required over two services per conception. The one cow family of high fertility had twelve conceptions from twelve services or an average of 1.00 service per conception. The other cow family of high fertility was made up of sixteen individuals which had thirty-two conceptions from thirty-nine services or 1.22 services per conception. The average for the twenty cow families with 479

TABLE 8

Average rate of conception for the daughters from nineteen sires

Sire	Breed	Daughters	Conceptions	Sterile females	Services to fertile females	Services per conception
		No.	*No.*	*No.*	*No.*	*No.*
Caesar	Ayrshire	16	41	3	72	1.76
Job	Ayrshire	5	8	0	16	2.00
Lefor	Ayrshire	5	6	0	7	1.17
Master	Ayrshire	17	47	2	90	1.91
Benedict	Guernsey	11	20	2	45	2.25*
Marose	Guernsey	12	34	2	62	1.82
Sequel	Guernsey	5	9	0	13	1.44
Teddy	Guernsey	11	20	3	25	1.25
Caliph	Holstein	11	23	1	39	1.70
Celman	Holstein	13	22	1	48	2.18
Garbon	Holstein	10	19	1	31	1.63
Judge	Holstein	20	49	2	85	1.73
Karmore	Holstein	9	14	0	20	1.43
Pan	Holstein	8	9	1	16	1.78
Quano	Holstein	10	20	0	31	1.55
Allor	Jersey	13	25	2	34	1.36
Fon	Jersey	7	22	1	31	1.41
Radiance	Jersey	6	12	2	23	1.92
Spicy	Jersey	15	22	0	32	1.45
Totals and average		204	422	23	720	1.71

* Highly significant.

conceptions from 822 services was 1.72 services per conception and twenty-eight females were sterile. One of the families with sixteen individuals and a total of forty-two conceptions had six sterile females. It is highly probable that this family carried a hereditary factor for sterility, and this was suspected from a practical viewpoint several years before this tabulation was made.

The average rate of conception for the daughters from nineteen different bulls is presented in table 8. Considerable differences can be observed in the conception rates between the daughters of various bulls. The 204 daughters from nineteen different bulls required 720 services for 422 conceptions or an average of 1.71 services per conception. There were twenty-

three sterile females, but none of the sires apparently had more than the expected numbers. The daughters of the sires ranged from 1.17 to 2.25 services per conception. The requirement of 2.25 services per conception for the daughters of one sire was highly significant and in all probability this sire transmitted this characteristic to his daughters. The next highest sire with 2.18 services per conception for his daughters very closely approached the level at which the results become highly significant.

SUMMARY

The breeding efficiency from artificial insemination over an eight-year period in the University of Nebraska dairy herd was analyzed. The summer and late summer months required more services per conception than did the months during the other seasons of the year. August was high with 2.24 services per conception and this is highly significant.

Results indicated that it was not possible to predict from the breeding efficiency of the previous year the number of services required for subsequent conceptions. The services required for conception in virgin heifers did not give any indication as to the number of services required for the following conception, for the average number of services required per conception throughout the lifetime of the individual, and no indication as to the number of services required for the first conception in her daughters. An analysis of the breeding histories for the cows sold as sterile showed that their previous breeding records gave no indication that sterility would follow.

Daughter-dam comparisons made for the average number of services required for all conceptions throughout the lifetime of the individual indicated that it is not possible to predict the breeding efficiency of daughters from the breeding records of their dams. However, when the services required per conception were tabulated by cow families, it was found that among twenty families there was one with very low fertility and two with extremely high fertility. Analysis of the breeding records for the daughters of nineteen bulls revealed one with daughters that required a highly significant number of services per conception and another sire that very closely approached this level.

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DETERMINATION OF GLUCOSE, GALACTOSE, AND LACTOSE IN THEIR MIXTURES

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In connection with a study of the manufacture of hydrolyzed lactose sirup (2) it was necessary to develop a procedure by which the amount of glucose, galactose, and lactose in the sirup could be determined.

The purpose of this paper is to describe briefly the method finally adopted, together with a discussion of its limitations. Included also are the results obtained when this procedure was used to determine the sugar content of four 30 per cent lactose sirups that were prepared in an autoclave by hydrolyzing them with acid.

The technique of analysis involves the use of Barfoed's modified reagent (9) for the determination of the sum of the two hexoses, in this case, glucose and galactose, and the use of Shaffer and Somogyi's procedure (5) and their reagent No. 50 for the determination of the reducing power of the mixed sugars before and after destruction of the glucose with bakers' yeast. From the results of these determinations, the amount of glucose, galactose, and lactose in the sirups can be calculated.

While the methods employed are not new, the technique of utilizing the modified Barfoed reagent to determine the galactose content eliminates the use of a selective ferment for the destruction of this hexose. Also, this procedure is easily adapted to routine analysis and does not require the preparation of selective ferments.

Scott and West (4) analyzed mixtures of glucose, galactose, and lactose by hydrolyzing the lactose with sulfuric acid, during the course of analysis. In their procedure, a galactose ferment was unnecessary. Coryell and Christman (1) used this technique, somewhat modified, in their study of the utilization of lactose by the fasting white rat.

Considerable attention has been given in the past to the Barfoed test for the estimation of hexoses in the presence of disaccharides and several modifications have been proposed to overcome its defects.

Sieben (6) eliminated the loss of acetic acid by confining the reactants in a closed tube and heating not over 40° C. Tauber and Kleiner (10) were unable to obtain reliable results with glucose solutions and explained the lack of agreement between duplicate analyses as due to loss of acetic acid and the formation of basic salts. They introduced a modification by substituting the non-volatile lactic acid in place of the acetic acid and found that their reagent did not reduce any lactose even when large amounts were used and the heating time was considerably prolonged.

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Steinhoff (8) added sodium acetate buffer, but Schapiro and Proferanzowa (3) found that Steinhoff's reagent reduced maltose, which was confirmed by Zerban and Sattler (11).

Svanberg (9) prepared a buffered Barfoed solution by adding sodium acetate and determined the precipitated cuprous oxide by dissolving the oxide in a sulfuric acid solution of ferric sulfate and titrating the reduced sulfate with permanganate. To prevent oxidation of the cuprous oxide, hydrogen was bubbled through the mixture while it was being heated. He found that pure solutions of glucose and galactose heated in boiling water for 6½ minutes with buffered Barfoed solution yielded similar copper reducing values when 1 to 3 mg. of these sugars were used. Also, the presence of lactose did not interfere unless the proportion of lactose to the monosaccharides was 10 to 1, in which case the reducing values were increased by 10 per cent.

EXPERIMENTAL

A modified Svanberg technique was used in this investigation. As Svanberg's reagent is saturated at room temperature it was diluted to prevent crystallization so that 1½ liters of the reagent contained 10.4 g. glacial

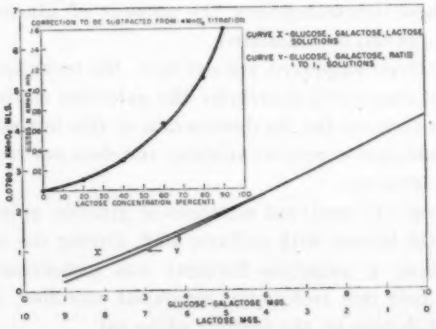
CURVE X - GLUCOSE, GALACTOSE, LACTOSE SOLUTIONS
CURVE Y - GLUCOSE, GALACTOSE, RATIO 1 TO 1, SOLUTIONS
LACTOSE CONCENTRATION (PERCENT)
GLUCOSE-GALACTOSE MGS.
LACTOSE MGS.

FIG. 1. Titration curves of sugar solutions containing glucose and galactose in ratios of 1 to 1 and glucose, galactose solutions of the ratio of 1 to 1 containing different amounts of lactose.

acetic acid, 66.5 g. cupric acetate and 7.0 g. sodium acetate. Also, since the purpose of this study was to determine the sugar content of sirups of approximately 30 per cent concentration, a considerable dilution error might be introduced if only 1 to 3 mg. of sample were used for the analysis as specified in the Svanberg procedure. Consequently, sirups containing approximately 10 mg. of sugar were taken for analysis. The use of these larger quantities necessitated an increase in the heating period from 6½ minutes to 10 minutes.

To maintain the same concentration of the reagent as recommended by Svanberg in the reaction mixture, the volume of sugar solution was reduced.

Preliminary experiments on pure sugar solutions indicated that results within a maximum error of 2 per cent could be obtained with these modifications. Since the glucose content is not dependent upon the results of this part of the determination, only the values for the galactose and lactose content would be affected. In a sirup of 30 per cent sugar content containing approximately 10 per cent glucose, 10 per cent galactose and 10 per cent lactose, a maximum error of 5 per cent of the total galactose or lactose might thus be introduced.

The results bear out Svanberg's contention that lactose slightly reduces copper in Barfoed solution. The magnitude of reduction of the copper by different concentrations of lactose in a mixture of glucose and galactose was determined and is shown in the insert in figure 1 and expressed in ml. of 0.0785 N $KMnO_4$. The permanganate titration values of these mixed sugars are shown in curves x and y. It is observed that these curves deviate slightly from a straight line, consequently a definite reduction factor will not hold

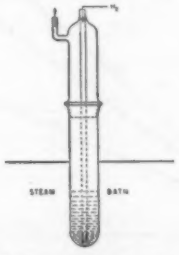

FIG. 2. Reaction tube in which the sugar and copper solutions were heated.

for all concentrations of mixtures of glucose and galactose. Samples only 10 per cent hydrolyzed, that is, containing 9 mg. of lactose and 1 mg. of hexoses when analyzed by this procedure would show, if not corrected, 3.5 per cent more hexoses than were actually present. However, only 0.03 per cent difference would occur if the sirup was 80 per cent hydrolyzed.

The test was performed by pipetting first 5 ml. of the diluted sirup containing approximately 10 mg. of sugar and 15 ml. of the buffered copper solution into a 1 × 6-inch tube. After the apparatus was assembled as shown in figure 2, the mixture was saturated with washed hydrogen. After the mixture had acquired the temperature of the bath, the rate of flow of the gas was adjusted to 30 bubbles per minute. When the total time of 10 minutes of heating had elapsed, the mixture was cooled immediately to 50° C. in cold running water. The cuprous oxide was then filtered through washed filter paper, with slight suction to hasten filtration, and washed twice with 10-ml. portions of water at a temperature of 60° C. The remainder of the test was similar to the procedure outlined by Svanberg—that is, the oxide was dissolved in sulfuric acid and ferric sulfate and the

reduced sulfate was titrated with standard potassium permanganate solution.

Under similar concentrations, differences in check analyses of the reducing values of either glucose or galactose solutions on Barfoed solution were greater than the differences between the mixtures of the two sugars. Consequently, even if the ratio of the two hexoses in the sirups was not exactly 1 to 1, a significant error would not result. The actual quantities of the two hexoses in the sirups were calculated from the curves constructed from mixtures of the two sugars in proportion of 1 to 1.

In figure 3 are presented the titration curves obtained on pure sugar solutions with the Shaffer and Somogyi procedure and use of their reagent No. 50 with 5 grams of KI. The only variation was to heat the mixtures in a steam bath instead of a hot-water bath. This method was also used on the

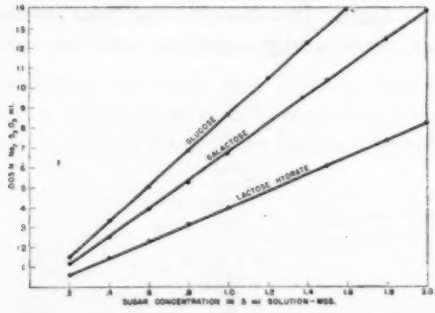

FIG. 3. Titration curves of pure sugar solutions, Shaffer and Somogyi method, reagent No. 50.

unknown sirup samples before and after fermentation with yeast. For the destruction of glucose with bakers' yeast, the procedure outlined by Somogyi (7) for the fermentation of glucose in blood was followed.

In the calculations of the percentage composition of the sirups, the titration equivalents of the sugars were obtained from the curves of figures 1 and 3, constructed from results obtained from the use of pure sugar solutions as previously indicated. These curves are presented since they were used in the calculations.

The results obtained by the application of this technique for the analysis of four samples of hydrolyzed lactose sirups are given in table 1.

The glucose content in all the sirups analyzed was somewhat less than the galactose content, which would indicate that galactose is more heat-stable under the conditions of heat and acidity used in the preparation of these sirups. However, this difference in the amounts of glucose and galactose apparently does not increase in proportion to the heating time, which may be due in part to the inaccuracies in the method of analysis. Also, on the

assumption that no galactose was destroyed in sirup No. 1, then approximately 16 per cent of the glucose was converted to by-products, which would represent 1.6 per cent by-products in the sirup. However, the difference between the total solid content, as determined by the oven method, and the sum of the three sugars was found to be only 0.75 per cent. Consequently,

TABLE 1

Procedure for steps in calculation of glucose, galactose and lactose content of four samples of hydrolyzed lactose from results of four analyses

Steps in calculation	Sirup identification No.			
	1	2	3	4
A. 0.0785 N $KMnO_4$ from 20 mg. sirup "Barfoed" (ml.)	1.39	1.92	2.15	2.16
B. Hexose equivs. of A from Fig. 1 Curve Y (uncor.) (mg.)	3.85	5.03	5.54	5.57
C. Hexoses in 4 mg. sirup [B ÷ 5] (mg.)	0.770	1.006	1.108	1.114
D. 0.005 N $Na_2S_2O_3$ from 4 mg. sirup before fermentation (ml.)	7.05	8.03	8.21	8.19
E. 0.005 N $Na_2S_2O_3$ from 4 mg. sirup after fermentation (ml.)	4.24	4.05	3.79	3.80
F. 0.005 N $Na_2S_2O_3$ from glucose in 4 mg. sirup [D − E] (ml.)	2.81	3.98	4.42	4.39
G. Glucose equivs. of F from Fig. 3 Curve A (mg.)	0.345	0.477	0.525	0.522
H. Galactose in 4 mg. sirup [C − G] (uncor.) (mg.)	0.425	0.529	0.583	0.592
I. 0.005 N $Na_2S_2O_3$ equivs. for gal. from H Fig. 3 Curve B (ml.)	2.72	3.45	3.86	3.93
J. 0.005 N $Na_2S_2O_3$ equivs. for gal. and glu. [F + I] (ml.)	5.53	7.43	8.28	8.32
K. 0.005 N $Na_2S_2O_3$ equivs. for lactose [D − J] (ml.)	1.52	.60	.....	.....
L. Lactose equivs. of K from Fig. 3 Curve C (mg.)	0.418	0.20	.....	.....
M. Lactose content of sugars [L ÷ (L + G + H)] × 100 (%)	35.2	16.5	.....	.....
N. 0.0785 N $KMnO_4$ cor. for lac. content. Insert Fig. 1 (ml.)	0.024	0.008	.....	.....
O. 0.0785 N $KMnO_4$ from A cor. for lactose [A − N] (ml.)	1.366	1.912	2.15	2.16
P. Hexose equivs. of O from Fig. 1 Curve Y (cor.) (mg.)	3.77	5.00	5.54	5.55
Q. Hexose equivs. of 4 mg. sirup corrected [P ÷ 8] (mg.)	0.754	1.00	1.108	1.110
R. Galactose in 4 mg. sirup corrected [Q − G] (mg.)	0.409	0.523	0.583	0.588
S. Glucose in sirup [G ÷ 4] × 100 (%)	8.6	11.9	13.1	13.1
T. Galactose in sirup [R ÷ 4] × 100 (%)	10.2	13.1	14.6	14.7
U. Lactose hydrate in sirup [L ÷ 4] × 100 (%)	10.4	5.0	.....	.....
V. Total sugars in sirup [S + T + U] (%)	29.2	30.0	27.7	27.8
W. Total solids by heating in vacuum oven (%)	29.95	30.06	30.06	30.36
X. By-products [W − V] non-volatile (%)	0.75	0.06	2.37	2.56

Sirups 1, 2, 3, and 4 hydrolyzed 35, 50, 65 and 80 minutes respectively as shown in the heat treatment curve figure 4—reference 2.

the chief errors of this procedure for analysis of this sirup are the undeterminable ones due to the by-products. However, in view of the fairly close checks of the sugar content as determined and the total solids, it would seem that the by-products formed in this sirup have no reducing effect, or at least only a small reducing effect, on either Barfoed or Shaffer and Somogyi reagents.

In the sirups that were hydrolyzed for 65 and 80 minutes there was an appreciable loss of sugars; 2.36 per cent in No. 3 and 2.56 per cent in No. 4.

SUMMARY

A method for determining the amount of glucose, galactose, and lactose in hydrolyzed lactose sirups has been outlined.

The procedure was to determine the sum of the two hexoses by means of a modified Barfoed solution, and the amount of glucose and lactose by following the directions of Shaffer and Somogyi before and after fermentation with washed bakers' yeast.

Four samples of hydrolyzed lactose sirups were analyzed by this procedure and the results and steps in the calculations are described.

Sirup No. 1, which attained a maximum temperature of only 143° C. at the expiration of 35 minutes, still contained 8.6 per cent lactose; whereas sirup No. 3, which was heated for 65 minutes, and 15 minutes of this time the temperature was 143–147° C., showed no lactose. There was, however, a loss of 2.37 per cent in sugar content, which was converted into by-products. The reducing values of these by-products were of negligible amounts.

The maximum error for the complete analysis should not exceed 7 per cent.

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THE ACID HYDROLYSIS OF LACTOSE AND THE PREPARATION OF HYDROLYZED LACTOSE SIRUP

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This paper reports an investigation of factors concerned in the hydrolysis of lactose by acids, including a study of the solubility of mixtures of glucose and galactose and of methods for the production of hydrolyzed lactose sirups. By hydrolyzing lactose into its more soluble hexose constituents, higher sugar concentrations could be obtained in some dairy products which otherwise might develop a "sandy" texture. However, the destructive effect of acid hydrolysis on proteins precludes this treatment on dairy products such as milk or whey. The milder method of enzyme hydrolysis is impractical because there are no known methods of economically preparing and concentrating large quantities of lactose. Browne and Ramsdell in a recent study (2) found the enzyme prepared from lactose-fermenting yeasts to be unstable and weak in hydrolytic power.

EXPERIMENTAL

U.S.P. grade lactose was used unless otherwise stated.

Most of the samples were hydrolyzed by batch heating but a few were hydrolyzed in a high-temperature circulating heater. For one method of batch heating 150-ml. portions of the lactose test solutions were sealed in small, well-tinned cans coated with an acid-resisting lacquer. The cans were heated in a pilot evaporated-milk sterilizer with the reel revolving at 4 r.p.m. Fifteen minutes was used to bring the cans to the required temperature and this time was not included in the reported holding times. The other method of batch heating involved the use of a 2-gallon, glass-lined, steam-jacketed, reaction kettle equipped with an agitator and with an outlet valve for removing samples. The highest hydrolysis temperatures used in this work were attained in a Mallory (5, 10) heating unit. When holding periods longer than the time required for passage of the liquid through the heater were needed, the sirup was recirculated until the desired heating time was reached. The flow time through the different parts of the heater were: heating unit—3 seconds, holding pipe—1 minute, cooling unit—3 seconds.

The polariscopic method for determining the degree of hydrolysis was tried, but the results indicated that there was some interference due to the by-products of hydrolysis; so the Munson and Walker gravimetric method (7) was used for most of the work. The concentrations of the different sugars in the finished hydrolyzed sirups were determined by a combination

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of methods described in another paper (9). The effect of the by-products of hydrolysis on the reduction of copper, was not studied but none of the values obtained showed more than the theoretical yield of glucose and galactose.

Mixtures of lactose and water containing as much as 800 grams of lactose per 1000 grams of mixture were used. Since the lactose only partly dissolved until the temperature of hydrolysis was approached, the concentrations of lactose and acid were expressed as the number of grams per 1000 grams rather than per liter.

Solubility determination of galactose and glucose in each other's presence were made by placing an excess of galactose in glucose solutions of various concentrations. The mixtures were placed in 125-ml. ground-glass-stopped bottles which were fastened to a motor-driven metal frame submerged in a water bath held at 25° C. Five days were allowed for the mixtures to attain equilibrium. Solubility measurements were made by carefully transferring filtered samples from the bottles to a weighing dish containing dry asbestos and drying to a constant weight in a vacuum oven maintained at 100° C.

RESULTS

For certain food purposes the use of an organic acid as catalyst during lactose hydrolysis might be advantageous. The effect of citric acid at different concentrations upon the reaction and the amount of inversion is shown in table 1. When the pH values obtained with citric acid are compared with the values for hydrochloric acid given in table 2 and with hydrolysis data presented in other parts of this paper, the superiority of the mineral acid as catalyst becomes apparent. The pH measurements given in these tables were made on the sirups after hydrolysis and, in consequence, there was a slight buffering action by the decomposition products produced during the heating.

The effects of different concentrations of lactose and of hydrochloric acid and of the temperature of heating for 60 minutes in small cans by the batch method, upon the hydrolysis of lactose are presented in figures 1 to 3. The acid concentration was plotted on a logarithmic scale.

The effects of highly concentrated lactose solutions were first studied because the product was to be prepared for food manufacture and the use of high concentrations would eliminate the need of subsequent condensing. Data on the hydrolysis of lactose solutions of different concentrations have been plotted in figure 1. The copper-reducing values of the 80 per cent and 55 per cent solutions indicated a rapid destruction of the sugars which increased with increased acid concentration.

The data plotted in figure 2 show the effect of the concentration of acid upon the hydrolysis of 10 per cent lactose solutions at temperatures from 100° C. to 145° C. At each temperature, over 90 per cent of the lactose was

TABLE 1

The effect of time of heating and the concentration of citric acid upon the hydrolysis of 50 per cent lactose solutions

Heating time at 121° C.	Citric acid per 1000 grs.	Reaction after heating	Inversion	Velocity constant
min.	*mole*	pH	%	$K \times 10^4$
15	None	3.56	None	.....
	0.0476	1.85	14.5	104
	0.0951	1.67	14.5	104
	0.1904	1.45	28.0	219
30	None	3.44	None	.....
	0.0476	1.80	24.0	91
	0.0951	1.67	23.0	87
	0.1904	1.41	41.0	176
45	None	2.87	None	.....
	0.0476	1.78	26.0	67
	0.0951	1.65	29.5	78
	0.1904	1.41	47.0	138
60	None	2.80	7.5	13
	0.0476	1.69	35.5	73
	0.0951	1.51	47.0	106
	0.1904	1.32	61.0	157
120	None	2.41	7.5	6
	0.0476	1.78	47.0	53
	0.0951	1.62	70.0	100
	0.1904	1.37	89.0	184

hydrolyzed when the maximum reducing value was reached and a destruction of reducing sugars became noticeable. The relationship (Fig. 3) between temperature of hydrolysis and the concentration of acid required to attain over 90 per cent hydrolysis was logarithmic for the data of figure 2.

A study was made to determine the amount of hydrolysis which could be obtained in a pressure kettle using a 7000-gram charge containing 30 per cent lactose by weight at an acid concentration of 0.007 moles per 1000 grams of solution. Results of a typical experiment are given in figure 4.

TABLE 2

The hydrogen-ion concentration of hydrolyzed lactose solutions

HCl per liter	Lactose concentration	
	10 per cent	30 per cent
mole	pH	pH
0.002	2.65	2.46
0.006	2.26	2.04
0.01	2.02	1.75
0.02	1.65	1.42
0.04	1.37	1.11
0.08	1.08	0.89
0.2	0.74	0.54
0.5	0.35	0.20

10 per cent solution heated for 60 minutes at 130° C.
30 per cent solution heated for 60 minutes at 134° C.

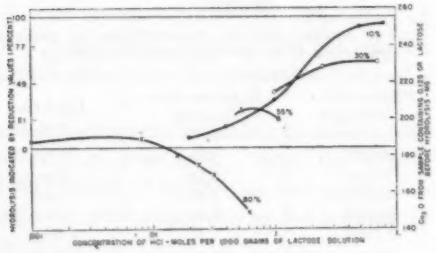

FIG. 1. The effect of the concentration of HCl upon the hydrolysis of lactose in solutions of different lactose concentrations. Each mixture was heated 60 minutes in cans at 100° C., except the 80% lactose mixture which was heated to 108° C.

Thirty minutes were required to attain a temperature of 140° C., but at this point almost 50 per cent of the lactose was already hydrolyzed.

The results shown in table 3 were obtained by hydrolysis with the circu-

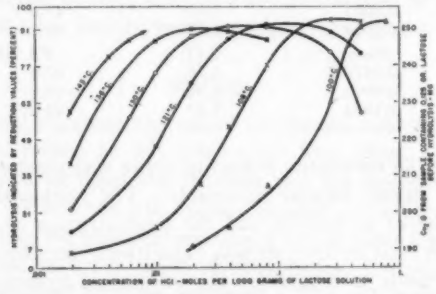

FIG. 2. The effect of the concentration of HCl upon the hydrolysis of lactose in 10% lactose solutions. Samples were heated for 60 minutes in cans at different temperatures.

lating method. It was possible to use temperatures up to 165° C. with this method of heating. A residue of milkstone was found coating the heating coil after the test in the last experiment of table 3 was started. This probably raised the pH slightly and in consequence lowered the reaction velocity.

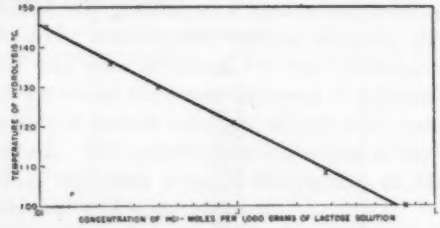

FIG. 3. Relationship between temperature and the concentration of HCl necessary to attain maximum hydrolysis (91% to 93%) of the lactose in a 10% solution during heating 60 minutes in cans.

TABLE 3

*Results from experiments on the circulating method of hydrolyzing lactose in pure solutions**

Lactose in solution	HCl per 1000 grams lactose solution	Heating conditions		Reaction after heating	Lactose hydrolyzed	$K \times 10^4$	Calculated time to invert 99.5%
		Temperature	Time				
%	*mole*	°C.	*min.*	pH	%		*min.*
33.6	0.034	130	36.0	1.23	82.0	476	111.3
29.0	0.023	130	58.8	1.46	79.7	271	195.4
28.4	0.023	140	30.0	1.47	84.5	622	85.3
23.2	0.019	165	8.2	1.60	79.0	1904	27.8
9.8†	0.020	165	10.5	1.70	79.0	1487	35.6

* The authors are indebted to R. W. Bell of these laboratories for assistance in the operation of the Mallory heater with which the samples in this table were hydrolyzed.

† A slight formation of milkstone formed from a previous batch of milk was found to have been present on the heating coil.

The effect of the temperature of hydrolysis upon the velocity of the reaction for both the retort and circulating methods is plotted in figure 5. The velocity constants K were calculated from the equation for a unimolecular reaction:

$$K = \frac{1}{t} \times 2.303 \times \log \frac{a}{a-x}$$

where x represents the amount of hydrolysis attained in time t, and a the initial concentration of lactose. When K is calculated for a period beginning with zero time and a is expressed in per cent hydrolysis, $a = 100$. For convenience of expression K is multiplied by 10^4.

The velocity constants of hydrolysis of 10 per cent lactose solutions by the batch method have been calculated for three acid levels and plotted in

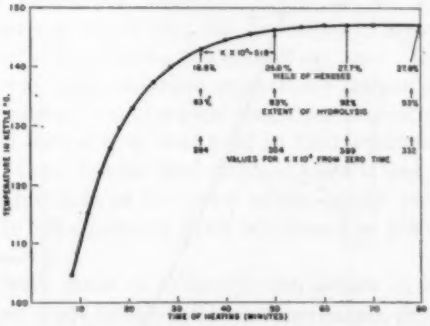

FIG. 4. Heating curve for hydrolysis of 30% lactose solutions in pressure kettle. Values indicating the degree of hydrolysis and the reaction velocity constant are given at 4 points on the curve. The concentration of HCl was 0.007 mole per 1000 grams of solution.

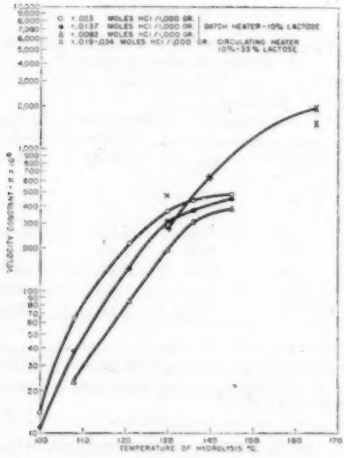

FIG. 5. The effect of the temperature of hydrolysis upon the rate of inversion of lactose during heating by batch and circulating methods. The values obtained with the circulating heater were taken from table 3; a curve has been drawn through three of these points representing samples containing approximately the same lactose and acid concentrations.

figure 5. All the K values given in table 3 for the circulating method have also been plotted on figure 5.

The solubility of galactose in glucose solutions at 25° C. was determined and the results are plotted in figure 6.

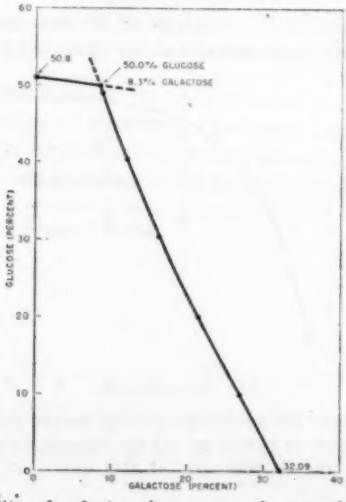

FIG. 6. Solubility of galactose in aqueous glucose solutions at 25° C.

The solubility of glucose is 50.8 per cent (4), of galactose 32.09 per cent (3), while the solution containing the maximum quantity of sugar consisted of 49.8 per cent glucose and 8.5 per cent galactose. The data indicate that an equimolecular mixture of the two sugars would be saturated with respect to each other when the concentration of each reached 21 per cent. The combined total of 42 per cent glucose plus galactose represents an important increase in solubility over the value of 17.7 per cent for lactose.

A procedure was developed for the preparation of a hydrolyzed lactose sirup suitable for use in foods. A charge consisting of 2100 grams of a good grade of recrystallized lactose, 49 grams of normal HCl and 4851 grams of water was introduced into a 3-gallon, glass-lined, double-jacket, steam-heated pressure kettle. The HCl concentration was 0.007 moles per 1000 grams of solution. The amount of acid used was held at a minimum to avoid the high salt concentration which would have resulted from neutralization of large quantities of acid. The heating was carried out in accordance with the time-temperature curve shown in figure 4, the mixture being stirred until the lactose dissolved. Seventy pounds of steam pressure was maintained throughout the heating period of 65 minutes, but 60 minutes of this time were required for the mixture to attain the desired temperature of 147° C. Upon completion of the heat treatment the mixture was treated with decolorizing carbon, filtered, and condensed under vacuum to 60 per cent solids content. The sirup was neutralized with sodium bicarbonate to give a reaction of pH 4.9–5.0. Sirups prepared in this manner contained practically no lactose, approximately 26 per cent glucose, 29 per cent galactose and 4 to 5 per cent of unidentified by-products (9). The product kept well at room temperature but showed a tendency to darken with age. The development of color in storage was more rapid when the reaction was adjusted to a higher pH, especially above pH 6. The concentration of hexoses in water was 58 per cent, but, according to figure 6, the sirup should be saturated with these sugars at about 42 per cent. Occasionally in sirups made in this way some galactose crystallized during storage, but most of the samples remained free of crystal formation even after months of storage.

Hydrolyzed lactose sirup was tried in food products where sweet sirups were needed. Good results were obtained when it was used as a sweetening agent in such products as ice cream mixes, candy, sweet baked goods and fruit whips. It had a pleasing flavor when used on hot cakes or as a topping for frozen desserts.

Attempts were made to hydrolyze the lactose in whey and in various preparations of crude lactose. These experiments produced dark caramelized products which contained much caramel and charred material. The protein and salts present in whey and crude lactose buffered the acid added to catalyze the reaction with the result that excessive quantities of acid were necessary. The results indicated that a hydrolyzed lactose preparation

acceptable for food uses should be prepared from a high grade technical or U.S.P. sugar.

DISCUSSION

A comparison of the effectiveness of hydrochloric acid and of various organic acids as catalysts in hydrolyzing lactose indicated that hydrochloric acid was best suited for this purpose. In view of the considerably lower degree of ionization of citric acid as compared with hydrochloric acid, it was found necessary to use 0.19 gram moles of citric acid to approach the reaction obtained with only 0.01 gram moles of hydrochloric acid. In the preparation of a hydrolyzed product for food purposes a low salt content was desirable but this did not result when a large quantity of organic acid was used since a correspondingly large quantity of salt was produced by neutralization.

Other investigators (1, 6, 8) have determined velocity constants for lactose hydrolysis in the presence of various quantities of acid and at temperatures below 100° C. Armstrong and Caldwell (1) hydrolyzed 18 per cent lactose with 0.5 molar HCl at 99° C. and found $K \times 10^4 = 334.2$. Polariscopic methods of analysis were used. Data from figure 2 show that a 10 per cent lactose solution heated at 100° C. with 0.5 molar HCl gave a value for $K \times 10^4 = 399.7$. The reaction velocity for lactose hydrolysis at 145° C., the highest temperature used in the batch method of heating, gave a value of $K \times 10^4 = 518$ (Fig. 4). In one experiment with the circulating heater at a temperature of 165° C., $K \times 10^4$ was 1904 (Table 3).

From the data it was clear that a gradual destruction of the newly formed hexoses accompanied the hydrolysis reaction. An analysis (9) of the sirups of 30 per cent sugar concentration prepared by heating in accordance with the heating curve in figure 4 showed that as the heating time progressed through 35, 50, 65 and 80 minutes the glucose concentrations were 8.6, 11.9, 13.1 and 13.1 per cent and the galactose concentrations were respectively 10.2, 13.1, 14.6 and 14.7 per cent. These figures indicate that the galactose was quite stable and most of the loss in hexose sugar was from destruction of the glucose. Another indication of sugar destruction was the formation of acid during hydrolysis as indicated by the differences in the pH of the 10 per cent and 30 per cent solutions shown in table 2.

Complete hydrolysis was not obtained as long as the curves of figures 1, 2, and 4 continued to rise toward the 100 per cent level. But none rose above 94 per cent of the theoretical yield which indicated some destruction of sugars had taken place. Loss in reducing sugar appeared to be greatest when attempts were made to hydrolyze highly concentrated solutions such as the 80 per cent sample, figure 1.

The calculated values for K were subject to a certain uncorrected error which was dependent upon the extent of destruction of the sugars during hydrolysis. The per cent hydrolysis was calculated from the theoretical

yield of hexoses formed and the actual values obtained by analysis (9). The effect of sugar destruction on the calculated K values is illustrated in the reduction of K at different heating periods, other conditions remaining constant (Table 1).

A substantial degree of hydrolysis of lactose in products such as whey or solutions of crude lactose was not attained without producing charred and caramelized by-products to an excessive degree. The occasional claim in dairy manufacturing literature and in some patent specifications that the lactose in whey or skim milk undergoes a significant degree of hydrolysis after a relatively mild processing at reactions of pH 4.0 or above would seem to be in error. The acid hydrolysis of the lactose in such products, containing, as they do, large quantities of milk protein, would be accompanied by a drastic breakdown in this protein material.

Many samples of hydrolyzed lactose sirup were prepared from good grades of lactose. It was found that a hydrolyzed mixture with a total solids content of 60 per cent or greater would generally keep well bacteriologically but would darken in color and in some cases show crystal formation. Although it was shown that an equimolecular mixture of glucose and galactose was saturated at 42 per cent, it was possible to raise the hexose concentration of the sirups as high as 55–60 per cent before crystallization of galactose occurred spontaneously. Evidently the presence of considerable quantities of hydrolytic by-products retarded crystal growth. Sirups which contained a total solids content in excess of 70 per cent often developed crystals after a few weeks storage.

SUMMARY

1. A study has been made of the factors affecting the hydrolysis of pure solutions of lactose by heat. The velocity constant ($K \times 10^4$) for the reaction varied with the time and temperature of hydrolysis and the acid and lactose concentration of the solutions. Values for $K \times 10^4$ ranged from 11 at 100° C. to 1904 at 165° C. Hydrochloric acid was used in concentrations of 0.001 to 1.0 mole per 1000 grams of solution and it was found to be a more effective catalyst than citric acid.

2. There was a progressive destruction of lactose and of the newly formed hexoses during hydrolysis. This destruction was accelerated by conditions of excessive or prolonged heating and when high sugar and acid concentrations were used.

3. Hexose sugars to the extent of 93 per cent of the theoretical yield were obtained by hydrolyzing a 30 per cent lactose solution using 0.007 mole of HCl per 1000 grams of mixture and heating to 147° C. The process, conducted in a glass-lined pressure kettle required a total time of 65 minutes, of which 60 minutes were used to heat the batch to 147° C. A circulating heater which would quickly raise the sirup to the hydrolyzing temperature would shorten the process.

4. A solubility curve for galactose in aqueous glucose solutions at 25° C. has been presented. The solubility of glucose at 25° C. is 50.8 per cent, galactose 32.09 per cent and a mixture of equal parts of both hexoses 42 per cent. The maximum concentration of the two hexoses which is soluble at 25° C. is 58.3 per cent, consisting of 49.8 per cent glucose and 8.5 per cent galactose.

5. The lactose in skim milk, whey or crude lactose, cannot be hydrolyzed without the usé of excessive quantities of acid and the production of undesirable protein decomposition products.

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SOME OBSERVATIONS ON THE KEEPING QUALITY OF SPRAY-DRIED WHOLE MILK STORED AT ROOM TEMPERATURE

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Oxidative deterioration of dried whole milk powder has been commonly attributed to the oxidation of the fat fraction. Our knowledge of the specific reactions involved is not complete, but the research work of various investigators has indicated that copper contamination of the milk and certain factors in processing, packing, and storage of whole milk powder are related to the shelf life of the product.

REVIEW OF LITERATURE

Holm and Greenbank (7) concluded from studies on the susceptibility of pure butterfat to oxidation that the quality of the milk from which the powder is made determines to some extent the keeping quality of the powder.

Forewarming the milk at higher than the ordinary preheating temperature (83° C. for 30 minutes) was found by Holm, Greenbank and Deysher (9) to improve the keeping quality of the powder, which is consistent with the findings of Jack and Henderson (11). Hollender and Tracy (6) have indicated that powder made from milk heated to 170° F. for 30 minutes is less likely to develop an oxidized flavor during storage than that made from milk heated to a higher (190° F.) or lower (150° F.) temperature for the same length of time.

Experiments by Holm, Greenbank and Deysher (9) showed that clarification of the milk improved the keeping quality of milk powder. It was thought that some enzymes or catalysts were removed by this treatment because returning the separator slime to the clarified milk resulted in a product with as poor a keeping quality as that made from unclarified milk. They suggested that the better keeping quality of cream powder over whole milk powder as observed by Supplee (17), may result from the beneficial effect of centrifugal separation.

Holm, Greenbank and Deysher (8) found that powder made from precondensed milk possessed better keeping quality than that made from uncondensed milk. They suggested that the removal during condensing of some volatile substances which act as catalysts may be the contributing factor in increasing the resistance of the fat to oxidation. Their results also showed that milk powder made from milk which was homogenized had better keeping quality than that made from unhomogenized milk.

The importance of the catalytic effect of copper on the development of tallowiness in milk powder has been shown by the work of Supplee (17).

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Milk held or heated in contact with copper was found to take up the metal in varying amounts, and powder made from the milk reflected the presence of the metal in its keeping quality.

Work reported by Waite (20), Hollender and Tracy (6), Tracy, Hoskisson and Trimble (18) and Jack and Henderson (11) has shown that the development of oxidized flavor in milk powder could be delayed by the addition of certain antioxidants to the milk before drying.

Holding powder under vacuum, in nitrogen, and in carbon dioxide gas was found by Supplee (17) to delay the development of the oxidized flavor. Data on storing partially skimmed powder under various oxygen concentrations indicated an improvement in storage life of powder packed under an atmosphere containing 2.5 per cent oxygen over that packed in atmospheres containing 5 per cent oxygen and a marked improvement over that stored in atmospheres containing 10 per cent oxygen and that which was air-packed.

In a report of a study on variations in the susceptibility of the fat in dry whole milks to oxidation, Holm, Wright and Greenbank (10) stated, "when judged by the olfactory sense, dry whole milk stored in carbon dioxide always produced off odors and flavors before they were detectable in samples stored in air or in partial vacuum." From their results it appears that carbon dioxide could not be classed as an inert gas toward dairy products containing fat. Results of the more recent work of Lea, Moran and Smith (12) do not support this contention.

Palmer and Dahle (13) suggested that the poorer keeping quality of spray-dried powder compared with roller dried powder may be due to the occluded air in the spray-dried product. Holm and Greenbank (7), however, doubted that occluded air was mainly responsible for the difference, and they further claimed that the rate of oxidation is not dependent so much on the availability of oxygen in quantity as upon susceptibility of the fat to oxidation. This idea is not in accord with the more recent studies of Lea, Moran and Smith (12).

In discussing the critical concentration of oxygen, Lea *et al.* (12) stated that reduction of the amount of oxygen in a can of gas or vacuum-packed milk powder has two effects: (a) it reduces the rate of oxidation, thereby extending the time required for the powder to develop a given degree of off flavor; and (b), it limits the degree of off flavor that can ultimately be reached. They considered a concentration of 0.03 milliliters oxygen per gram of powder as satisfactory, but, after extended storage periods, differences could be noted between powder stored in the presence of 0.01 milliliters oxygen per gram, 0.02 milliliters oxygen per gram, and 0.03 milliliters oxygen per gram. Powder stored in the presence of 0.04 milliliters oxygen per gram was definitely inferior to samples stored in lower concentration of oxygen, and furthermore they indicated that this concentration could not be accepted as satisfactory, especially when stored at elevated (37° C.) temperatures.

The fact that the storage life of whole milk powder decreases as the temperature of storage increases has been shown by Dahle and Palmer (2), Supplee (17), Holm, Wright and Greenbank (10), Hollender and Tracy (6), and Lea, Moran and Smith (12).

PLAN OF STUDY

This is a report of a preliminary study of the storage properties of whole milk powder, made in a manner believed to favor good keeping quality; *i.e.*, the powder was made from high quality fresh milk, clarified, preheated to 180° F. for 10 minutes, condensed 3–1, and spray-dried. An attempt was made to keep copper contamination to a minimum. The importance of each of the following factors was studied: 1) per cent oxygen in head space; 2) addition of the antioxidants, wheat germ oil and sodium arabo ascorbate; 3) spraying method; and 4) packing temperature. Changes in oxygen concentration in the headspace gas, ascorbic acid changes and changes in palatability were observed.

EXPERIMENTAL METHODS

Thirteen hundred and fifty pounds of fresh milk from the University herd was standardized to a fat-solids ratio of 1–3.54 with skim milk from the same milk source. The standardized milk was heated to 90° F., clarified, and then forewarmed at 180° F. for 10 minutes. After cooling to 150° F., it was condensed approximately 3 to 1 in a 3-foot stainless-steel vacuum pan. The condensed milk was homogenized at a temperature of 120° F. using 1000 pounds pressure and cooled over a stainless-steel surface cooler to 40° F. The condensed milk was stored in aluminum cans and held at 40° F. over night. The cans were then jacketed and taken to the laboratory of the Indiana Condensed Milk Company at Lebanon, Indiana, and made into six batches of powder, using a small experimental spray-drier. The powder was made August 3, 4, and 5, 1943.

The general drying procedure was as follows: The condensed milk was forewarmed to 140–145° F., and spray-dried, using a number 69 nozzle at 250 pounds spray pressure. Air inlet and outlet temperatures were approximately 300° F. and 180° F. respectively. One batch was sprayed with a number 79 nozzle at 2000 pounds pressure to vary the texture and particle size of the powder. In the batches containing antioxidant, the antioxidant was added to the condensed milk before spraying.

After drying, the powder was uniformly mixed and packed in number 1 tin cans, the packing temperature and weight of powder per can being noted. After sealing, some of the cans from each batch were gas-packed immediately. An absolute pressure of 2–5 millimeters mercury was used.

Equilibrium oxygen concentrations in the headspace gas were determined for each series by plotting per cent oxygen versus days after sealing. These oxygen values were secured by the manometric procedure of Van Slyke and

Sendroy (19). The sampling procedure used was very similar to that of Lea, Moran and Smith (12), the lines being evacuated and tested for leaks before puncturing the cans. From the equilibrium oxygen values, density of air-free powder and packing density, the milliliters oxygen per gram of powder were calculated.

Fat, moisture, acidity, solubility, and bacteria count were determined according to accepted methods (4), except that data on any determination involving reconstituted milk are on the basis of 14 grams powder plus 100 milliliters distilled water. It was found that this procedure yielded milk with more nearly normal composition, freezing point, acidity, and organoleptic similarity than by reconstituting 13 grams powder with 100 milliliters water.

The ascorbic acid content, determined on milk, condensed milk and freshly prepared powder by the method of Sharp (16), is reported on the basis of milligrams per liter of reconstituted milk. The values for stored powder (9, 12 months) were determined by the method of Doan and Josephson (3). This procedure involves precipitation of 25 milliliters of reconstituted milk with 26.5 milliliters of a precipitant containing 6 per cent trichloracetic and 4 per cent metaphosphoric acids, filtering and titrating 20 milliliters of the filtrate with 2.6 dichlorobenzenone indophenol. It is thought that this procedure eliminates interference from possible reducing substances which may react with the dye. Lower values on powder stored 12 months were secured by this procedure than were secured by the direct titration procedure, while little difference was noted in the batches when the comparison was made at nine months.

The copper content of the milk powders was determined by the carbamate method described by Hetrick and Tracy (5) and the iron by the 1,10-phenanthroline method of Pyenson and Tracy (14).

The flavor score was determined on reconstituted milk scored shortly after reconstituting according to the following guide:

Excellent	23 and above
Good	20–22.5
Fair	17–19.5
Poor	12–16.5
Very unpalatable	below 12

All the powders reported in these experiments were stored in a room where the temperature was automatically controlled at 72° F. except during the summer months when the outside temperature was higher.

EXPERIMENTAL RESULTS

A. Analytical and packing data. The analytical data on the milk and condensed milk used for this experiment are given in table 1.

The fresh milk used was of good quality. The feed flavor in the raw milk mostly disappeared during forewarming and condensing. A cooked flavor,

TABLE 1

Analytical data of milk before drying

	Raw milk	Forewarmed milk	Condensed milk
Fat, percentage	3.4	.....	10.10
Total solids, percentage	12.03	.....	36.26
Acidity, percentage	0.15	0.145	0.47
Ascorbic acid, mg./liter	17.8	11.6	10.8*
Bacteria count/ml.	9600	.....	780*
Flavor score	22.0 (feed)	20.0 (cooked)	21.5* (cooked)

* Reconstituted to 3.4% fat.

which was very noticeable in the milk after preheating, became much less intense after condensing and spray-drying and the cooked flavor present in the reconstituted powdered milk was even less. All the batches of powder reconstituted immediately after drying scored 21.75.

A 35 per cent loss of ascorbic acid accompanied forewarming and a small loss resulted from condensing. The ascorbic acid values of the freshly reconstituted powders varied from 8.6–7.8–7.2–6.8 mg./liter as the age of the condensed milk before drying increased from 19–22–23–66 hours, respectively.

TABLE 2

*Analytical and packing data of dried milk**

Variable	Control No. 1	Spraying method	Addition of 0.2% wheat germ oil (fat basis)	High temp. pack.	Addition of 200 p.p.m. sodium arabo ascorbate (milk basis)	Control No. 2
Batch	1	2	3	4	5	6
Age of condensed milk before drying, hrs.	19	22	23	42	44	66
Fat, percentage	27.33	27.15	27.20	27.33	27.33	27.33
Moisture, percentage	2.1	2.3	2.5	2.0	2.2	2.2
Solubility index	.1	.1	.1	.2	.1	.1
Acidity, percentage	0.14	0.14	0.14	0.135	0.14	0.14
Ascorbic acid, mg./l.	8.4	7.8	7.2	6.8	122	6.8
Copper, p.p.m.	1.00	0.85	1.00	0.90	0.85	0.85
Iron, p.p.m.	7.6	7.0	5.6	4.9	4.8	5.2
Packing temperature	124° F.	140° F.	126° F.	162° F.	124° F.	122° F.
Packing density, g./ml. container vol.	0.603	0.525	0.647	0.623	0.647	0.617
Equilibrium, % O_2	1.65	1.45	1.50	1.65	1.3	1.3
Ml. O_2/gram powder	0.0147	0.0164	0.0117	0.0138	0.0100	0.0110

* The spraying method for all except batch two involved the use of a number 69 nozzle and 250 pounds spray pressure. These powders were coarse in texture and almost crystalline in nature. The powder in batch two was made with a number 79 nozzle and 2000 pounds spray pressure. This powder was very fine and fluffy in texture and yielded the lowest packing density. (Grams powder per milliliter container volume.)

In the case of batch four, after completion of drying, air at a temperature of 200° F. was circulated over the powder in the drier for approximately ten minutes. This treatment raised the temperature of the powder about 40° F.

Analytical and packing data on the batches of milk powder are given in table 2.

There were no appreciable differences in the copper content or per cent moisture among the six batches. Some iron contamination evidently occurred in the first two batches. The powders were all efficiently gas-packed; some variations in oxygen content per gram of powder among the batches occurred, but the values for all lots fall in the range set by Lea, Moran and Smith (12) as satisfactory.

B. Storage observations of packaged powder. Acidity, pH, and solubility measurements made on all samples of powder at various intervals

TABLE 3

Changes in oxygen concentration in headspace gas, ascorbic acid, and palatability of the gas-packed powders on storage

Batch No.	Treatment	Days of storage at room temperature				
		-	Initial	93	186	375
1	Control No. 1, No. 69 nozzle, 250 pounds spray pressure, age of condensed milk—19 hrs.	% oxygen*	1.65	1.58	1.35	0.53
		Ascorbic acid	8.4	8.1	7.7	5.7
		Flavor	21.75	20.5	20.0	18.0
2	Spraying method, No. 79 nozzle, 2000 pounds spray pressure	% oxygen	1.45	1.45	1.19	0.47
		Ascorbic acid	7.8	7.0	6.3	5.7
		Flavor	21.75	19.5	19.5	18.0
3	Wheat germ oil added, 0.2% (fat)	% oxygen	1.50	1.40	0.96	0.61
		Ascorbic acid	7.2	6.5	6.3	4.8
		Flavor	21.75	20.0	19.5	19.0
4	High temp. pack	% oxygen	1.65	1.05	1.08	0.63
		Ascorbic acid	6.8	7.0	6.3	5.7
		Flavor	21.75	20.5	20.5	19.0
5	Addition of 200 p.p.m. sodium arabo ascorbate	% oxygen	1.30	0.75	0.73	0.38
		Ascorbic acid	122	114	116	115
6	Control No. 2, No. 66 nozzle, 250 pounds spray pressure, age of condensed milk—66 hrs.	Flavor	21.75	20.5	20.5	18.0
		% oxygen	1.30	1.12	1.09	0.98
		Ascorbic acid	6.8	7.0	6.2	6.4
		Flavor	21.75	20.5	20.0	18.5

* Initial value for oxygen is equilibrium concentration.

throughout the 375-day storage period did not reveal any significant changes. The acidities of the reconstituted powders were 0.14 per cent $\pm$ 0.005 per cent, the pH values were 6.7 $\pm$ 0.02, and the maximum solubility change was $\pm$ 0.05 ml.; these variations fall within the range of experimental error.

Oxygen concentration in the headspace gas gradually became lower, the ascorbic acid content of the powder decreased, and the powder became slightly less palatable as the storage period advanced (table 3).

Although the values are not recorded in the table, the carbon dioxide content of the headspace gas increased as the oxygen content decreased, indicating that carbon dioxide is an end product of some reaction involved. The values for carbon dioxide were small, reaching approximately 0.4 per cent of headspace gas in gas-packed powders and approximately 0.8 per cent in

air-packed powders at the 375-day storage interval. As Lea, Moran, and Smith (12) have indicated, the rise in carbon dioxide content is not of the same order of magnitude as the fall in oxygen. It is quite possible, however, that part of the carbon dioxide formed may have been absorbed by or dissolved in the milk constituents.

There was a tendency toward more carbon dioxide production in the powder containing sodium arabo ascorbate than the other lots, but this difference was only about 0.1 per cent carbon dioxide at 375 days storage, which may be within the range of experimental error.

Gas-packed samples. The data in table 3, which represent only the gas-packed samples, do not show significant differences among the variables studied as indicated by flavor scores. Under the conditions of this experiment with samples properly gas-packed, the spraying method, packing temperature, addition of the antioxidants—wheat germ oil and sodium arabo ascorbate, and age of the condensed milk were not important factors. None of these samples were considered to have the typical oxidized fat flavor and examination of samples 2, 3, 5, and 6 after 540 days storage showed no appreciable change in flavor from that observed at 375 days storage.

The fall in flavor score during the first 186 days of storage was attributed to a lack of fresh flavor or a staleness, which may be due to some reaction other than an oxidation of the fat.

Peroxide values determined by the method of Chapman and McFarlane (1) were run on these samples after six months storage and all except sample number 5 showed no peroxide value. This in itself is not significant (15), but coupled with the fact that no oxidized flavor was detectable it seems to indicate that the fat had not been oxidized to any great extent. At the same time some oxygen was absorbed which cannot entirely be accounted for by the corresponding fall in ascorbic acid values. For example, in sample 1, the fall in oxygen concentration was 0.3 per cent, which is equivalent to approximately 0.5 ml. oxygen (neglecting the pressure drop which accompanies absorption of oxygen). If one atom of oxygen oxidized 1 mole of ascorbic acid (M. W. 176), 7.8 milligrams ascorbic acid would be oxidized by the 0.5 ml. of oxygen. Actually a total loss of only 0.93 milligrams ascorbic acid was observed.

Lea, Moran and Smith (12) have shown that spray-dried skim milk powder absorbs oxygen at a slow uniform rate. It is entirely possible that with powder packed in an atmosphere low in oxygen, most of the oxygen in the container could be absorbed by the non-fat milk solids before the induction period of the fat is expended. The absorption of this oxygen by the non-fat solids may be associated with the typical loss of fresh milk flavor evidenced in the early stages of storage of whole milk powder.

Air-packed samples. The data for the air-packed samples of the first five batches are shown graphically in figure 1. Oxygen absorption was more

rapid, more ascorbic acid was lost, and a greater change in palatability occurred in air-packs than in the gas-packed samples. All the samples possessed an oxidized flavor after 375 days in storage; however, some differences in palatability were observed.

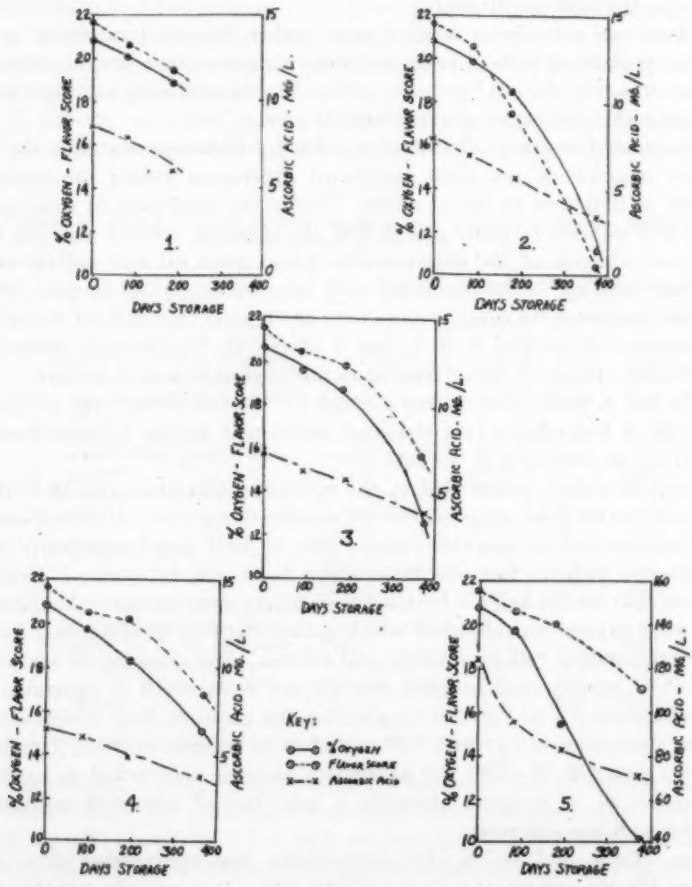

FIG. 1. Changes in oxygen concentration, ascorbic acid, and palatability of whole milk powder packed in air.

Curves for batches 3 and 4 show that after a fall in the oxygen content of the headspace gas of 2–3 per cent occurred, the flavor curve began to fall more rapidly with increasing amounts of oxygen absorbed.

Attention is called to batch 5, which showed the greatest amount of oxygen absorbed and yet had consistently less oxidized flavor than the others.

This batch of powder contained added sodium arabo ascorbate. The fall in titration value calculated as ascorbic acid would indicate that some oxygen absorption could be attributed to the destruction of the ascorbate. Both air pack and nitrogen pack samples containing this antioxidant developed a different type flavor resembling the cooked and stale flavors.

Oxygen absorption also occurred more rapidly in batch 2, which was sprayed at a higher pressure. As previously mentioned, this treatment produced fine-textured, light, fluffy powder, presumably having greater surface area exposed per gram of powder than powder from the other lots. Accompanying the absorption of oxygen was a much more rapid loss in palatability. At the 375-day examination, it was deemed very unpalatable, by far the poorest sample in the experiment.

Data on batches 3 and 4 indicate slightly less oxygen absorption in the high temperature pack and a flavor change comparable to that of the sample containing wheat germ oil.

Because of experimental difficulties (leakers) no sample of the number 1 batch was available for examination at the year's observation period. From the comparisons made at the end of the sixth month period, it can be said that a slightly better flavor was observed in samples having added antioxidants and those packed at the higher temperature than the control sample. A marked increase in the speed of off flavor development in the air-packed samples resulted when the milk was sprayed at the higher pressure. This was probably related to the increased surface area of the smaller particles produced at the higher spray pressure.

C. Relation of oxygen content of the headspace to the keeping quality of gas-packed powder. To study the importance of the amount of oxygen in the headspace, powder from batch 6 was used. Atmospheres of various oxygen contents were secured by evacuation to 3 millimeters, 12 millimeters, 25 millimeters, and 50 millimeters mercury absolute pressure and releasing vacuum with nitrogen. A fifth series of samples was held 20 hours in carbon dioxide and then gas-packed with a mixture of 50 per cent carbon dioxide and 50 per cent nitrogen.

The oxygen, ascorbic acid and flavor changes, recorded in table 4, show a tendency toward greater loss in palatability and ascorbic acid as the percentage of oxygen in the atmosphere in which they were stored increased. Since there was a considerable amount of oxygen in the headspace gas in samples 5212, 5213, and 5214 after 375 days' storage, it is to be expected that as these oxygen values approach zero even greater differences in palatability would be observed. Samples 5211 and 5212 were examined after 540 days' storage. Sample 5212 was slightly oxidized while sample 5211, considering the length of the storage period, showed little change over the 375-day examination. The difference in score was two points. Sample 5215 changed very little in palatability, which lends support to the belief that

TABLE 4

Changes in oxygen concentration, ascorbic acid and flavor on storage of milk powder samples gas-packed in atmospheres of various oxygen concentrations

Sample	Gas-packing method	% oxygen in headspace				Mg./l. ascorbic acid				Flavor score			
		Days storage								Days storage			
		Equilib.	93	186	375	0	93	186	375	0	93	186	375
5211	Evacuated to 3 mm.	1.30	1.12	1.09	.98	6.8	7.0	6.2	6.4	21.75	20.5	20.0	18.50
5212	Evacuated to 12 mm.	2.70	2.46	2.19	1.22	6.8	6.5	5.8	5.9	21.75	20.5	20.0	18.25
5213	Evacuated to 25 mm.	3.50	3.53	3.11	2.20	6.8	6.5	5.8	5.2	21.75	20.5	19.5	18.0
5214	Evacuated to 50 mm.	4.80	4.60	4.59	3.43	6.8	5.9	4.8	4.6	21.75	20.5	19.5	17.5
5215	Held in CO_2 20 hrs. Evacuated to ½ mm. and gassed with 50% N_2, 50 CO_2	0.65 Approx.	0.61 71% CO_2	.....	0.16	6.8	7.0	.....	6.2	21.75	20.75	.....	20.0

extremely low oxygen content is desirable in lessening the magnitude of the initial loss in palatability caused by factors other than fat oxidation. It also demonstrates, at least in the presence of small amounts of oxygen, that a mixture of nitrogen and carbon dioxide is satisfactory for storing milk powder.

Data for these lots are shown graphically in figure 2. The rate of oxidation was not appreciably different in samples stored in atmospheres of 2.7, 3.5, and 4.8 per cent oxygen. It is probable that susceptibility of the fat to oxidation, copper content, and surface area of powder exposed to the atmos-

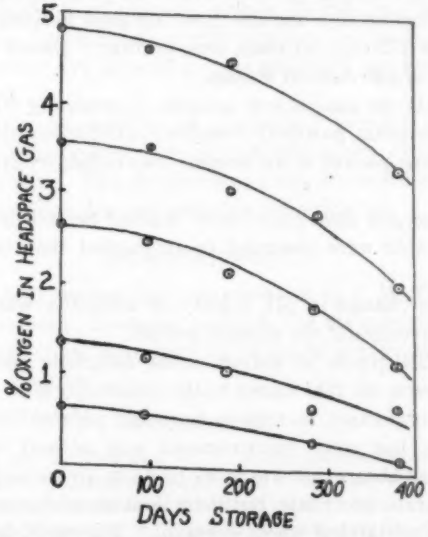

FIG. 2. Changes in oxygen concentration in headspace gas of whole milk powder packed in atmospheres of varying oxygen content.

pheres are factors. From the shape of the curves it is evident that these samples at 375 days were beginning to show accelerated oxygen absorption, indicating that the induction period of the fat was expended. Little oxygen for absorption by the fat remained in sample 5215 at 375 days. It is thought that differences in palatability among the samples would have become greater as the oxygen values for the other samples approached zero.

D. Relation of multiple gas packing to keeping quality. The effect of multiple gas packing was studied on the powder from batch 5 (containing sodium arabo ascorbate). After drying, the powder was gas-packed immediately. After 24 hours and after 9 days a series of cans were regassed. The equilibrium oxygen values on these series were 1.3 per cent, 0.75 per cent and 0.55 per cent, respectively. Data on oxygen absorption, fall in ascorbic acid, and flavor were also taken at the same periods. Within limits of determi-

nation all the oxygen was consumed after the 375 days' storage and none of the samples possessed a typical oxidized flavor. Only slight differences were noted in palatability among the three series, and it should be stated that all possessed a pronounced cooked flavor. The per cent reductions in titration value, calculated as ascorbic acid, were 5.9 per cent, 4.1 per cent and 0.8 per cent for the 375-day storage period; the original value was 122 mg./l. calculated as ascorbic acid.

DISCUSSION AND SUMMARY

Data are given relating to observations on the keeping quality of whole milk powder processed in a manner favoring good keeping and stored in air and nitrogen for 375 days at room temperature. (Some observations were made at the end of 540 days of storage.)

In general, all the gas-packed samples (containing 0.0100–0.0164 milliliters oxygen per gram powder) remained satisfactory during 375 days of storage, while those packed in air became unsatisfactory from the standpoint of palatability.

More rapid oxygen absorption, more evolved carbon dioxide, and greater loss in ascorbic acid were observed in air-packed than in nitrogen-packed samples.

No significant change in pH, acidity or solubility was observed on any of the samples throughout the storage period.

Addition of 200 p.p.m. of sodium arabo ascorbate (milk basis) and 0.2 per cent wheat germ oil (fat basis) to the condensed milk before drying did not prove to be important factors in lessening palatability changes of gas-packed powders, but some improvement was noticed in the air-packed powders. Oxygen absorption was more rapid in air-packed samples containing the sodium arabo ascorbate, but deterioration of flavor was not as rapid as in the powder containing wheat germ oil. The rapid fall in the titration value (calculated as ascorbic acid) of samples containing sodium arabo ascorbate indicated that oxygen was being utilized in the oxidation of the ascorbate. Samples containing sodium arabo ascorbate possessed a different flavor, resembling a cooked flavor.

More rapid oxygen absorption and greater loss in palatability was observed in air-packed powder sprayed with a number 79 nozzle at 2000 pounds pressure than in the controls sprayed with a number 69 nozzle at 250 pounds pressure. A lower packing density and a lighter, fluffier, textured powder with presumably greater surface area exposed were secured by this variation in spraying pressure. This may account for differences in the rate of oxygen absorption and suggests the desirability of a larger particle size.

Powder stored in atmospheres containing at equilibrium different amounts of oxygen (2.7–4.8 per cent) showed a tendency toward greater loss in palatability and ascorbic acid throughout the storage period as the equilibrium oxygen percentage was increased. Differences in palatability

among the samples in this series were not particularly great even at the 375-day storage period, all having fallen 3 to 4 points in flavor score. The oxygen contents had not fallen to zero after 375 days and the amounts remaining were considered sufficient to cause progressively greater differences in palatability as the storage period lengthened. Observation on two of these series after 540 days of storage strengthened this belief. A series from this same lot of powder stored in an atmosphere containing 71 per cent carbon dioxide and 0.65 per cent oxygen at equilibrium showed very little change in palatability after 375 days of storage. This indicates that, at least in the presence of small amounts of oxygen, carbon dioxide can be considered a satisfactory gas to use in combination with nitrogen for storing milk powder; in fact, the sample after 375 days of storage possessed the best flavor of any lot in the experiment.

The initial loss in palatability of gas-packed powder on storage was thought possibly to be associated with oxygen absorption by or reaction with some non-fat constituent. This flavor change was described as a loss of fresh flavor or a staleness which did not resemble fat oxidation.

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PROPIONIC ACID, SODIUM PROPIONATE AND CALCIUM PROPIONATE AS INHIBITORS OF MOLD GROWTH. I. OBSERVATIONS ON THE USE OF PROPIONATE–TREATED PARCHMENT IN INHIBITING MOLD GROWTH ON THE SURFACE OF BUTTER[1]

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The control of mold growth in the interior and on the surface of butter offers a serious problem. A large part of the moldy butter difficulty has manifested itself in surface discoloration. This may be accounted for by the assumption that sufficient attention has not been given to the prevention of air-borne contamination of butter surfaces. Such contamination may occur at various stages of manufacture, probably the most important of which is during the packing and printing operations. One approach to the control of surface mold growth on butter is the treatment of parchment paper that comes into contact with butter surfaces. Certain chemicals (5, 7, 9, 11, 12, 14) have been employed or recommended for this purpose with the hope that retention of these agents by the paper when in contact with the butter surface, would serve to inhibit and possibly prevent the growth of mold.

Salt treatment of tubs, liners and wrappers has been a time-honored method of mold control. Its greatest application has been to salted butter, on which, incidentally, mold is less of a problem than on unsalted butter. Various procedures for its use have been recommended (1, 2, 3, 4, 6, 8, 10, 11, 16), all utilizing a concentrated salt solution for the treatment of parchments.

In a preliminary study, Macy and Olson (12) found parchment paper treated with aqueous solutions of sodium and calcium propionate quite effective in restraining mold growth on butter heavily seeded with mold spores before wrapping. Calcium propionate was found to be more effective than the sodium salt. Both were more effective on salted than on unsalted butter. Ingle (9) reported that a six per cent calcium propionate solution or a twelve per cent solution of sodium propionate greatly inhibited mold growth on the

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[2] On military leave of absence for duty with the Medical Department, Army of the United States.

surface of unsalted butter stored at 60° F. and 100 per cent relative humidity. He reported that dry propionate-impregnated wrappers when wetted previous to wrapping gave better results than using them dry. In our experience quite the opposite has occurred. Thomsen (15) observed that yeast and mold counts on the surface of butter packed in tubs or boxes lined with parchment dipped in twelve per cent propionic acid were reduced about twenty per cent.

Since these propionate compounds are apparently innocuous and are natural constituents (13) of butter, and other dairy products, they seemed worthy of more intensive investigation. This paper is an extension of our preliminary study in determining the effectiveness of the propionates in inhibiting mold growth on butter surfaces wrapped in parchment treated primarily in calcium propionate solutions. It became evident early in the work that calcium propionate was the superior salt for this purpose. Studies pertaining to the active agent responsible for the inhibiting effect of the propionates will be the subject of another report.

METHODS

Quarter-pound prints of a 93-score commercial brand of unsalted butter were cut in half, transversely, and the one-eighth pound prints were used in these studies.

In most of the work, butter surfaces were artificially contaminated by spraying a mold-spore suspension of a known species on the surfaces by means of an atomizer. The suspensions were prepared by scraping mycelium and spores from an agar plate or slant and dispersing this material in sterile distilled water. Spores predominated in most cases and for the sake of brevity, the suspensions are called "spore suspensions."

Immediately after contamination, the prints were wrapped by hand with parchment paper which had been immersed in propionate solutions of various concentrations prepared on a weight-volume basis. For example, the preparation of an eight per cent solution of calcium propionate consisted of weighing out eight grams and making it up to a total volume of 100 milliliters with distilled water.

Throughout this study, storage conditions were maintained which would be as severe as any which might be encountered in regular commercial trade channels. To obtain such a condition, ordinary household refrigerator humidors were used for storing the butter. The relative humidity was maintained at approximately 100 per cent and the temperature at 45°–48° F. The samples were observed at various intervals depending on conditions of the experiment.

EXPERIMENTAL

I

On the basis of previous results there seemed to be little advantage in using concentrations of calcium propionate above ten per cent for the treat-

ment of parchment butter wrappers to prevent subsequent mold growth on the surface of salted or unsalted butter during storage. However, preliminary studies showed that lower concentrations in acidified solution could be used and approximately the same results obtained. A comparison of the effect of these solutions on several species of mold was made.

The following solutions were prepared: 1) 10 per cent calcium propionate pH 8.3; 2) 10 per cent calcium propionate pH 5.5; 3) 5 per cent calcium propionate pH 7.9; 4) 5 per cent calcium propionate pH 5.5; 5) 5 per cent calcium propionate pH 4.5; 6) control (sterile distilled water). Lactic acid was used to acidify solutions 2, 4, and 5. The pH of solutions 1 and 3 was not adjusted.

All solutions were heated to 175° F. before use. Preliminary trials revealed that heating propionate solutions to 180° F. did not reduce their effectiveness in inhibiting mold growth. Likewise no significant difference was noted between the pH of the solutions before and after heating.

Spore suspensions were made using the following species: 1) *Hormodendrum cladosporiodes;* 2) *Alternaria tenuis;* 3) *Stemphylium congestum;* 4) *Phoma betae;* 5) *Cladosporium sp.;* 6) *Penicillium expansum;* 7) *Aspergillus niger.*

After spraying the surfaces, the prints were wrapped with sterile parchments which had been soaked in the various propionate solutions for at least five minutes. Each lot of butter, sprayed with a particular species, was stored separately in a humidor and all prints were examined every day. A triple thickness piece of cheesecloth was placed beneath the cover of each humidor and kept moist for the purpose of maintaining a saturated atmosphere during storage. The results of this experiment are shown in table 1. To conserve space the data showing inhibition of *A. tenuis* and *Phoma betae* are not included. Prints sprayed with these species remained mold-free until 24 days storage, when scanty growth appeared on a few prints. However, no growth was evident at that time on prints wrapped with the five per cent acidified solutions. In almost every case the acidified five per cent calcium propionate solutions were equal or superior to the ten per cent calcium propionate solutions in preventing surface molding. The exceptions were: 1) *Cladosporium sp.* 10 per cent acidified and, 2) *Aspergillus niger* 10 per cent unacidified solution. It may be observed that considerable difference existed between species with respect to their resistance to the inhibitory effect of various calcium propionate solutions.

During the course of these investigations, samples of dry propionate-impregnated parchment, later placed on the market under the trade name of "Mycoban" impregnated parchment, were submitted for study. Another firm also submitted several samples of parchment impregnated with a different product thought to be a mold-growth inhibitor. This product is designated as "X." Several trials were made to determine their effectiveness in

TABLE 1

The effect of parchment treated in calcium propionate solutions at various pH levels on the growth of several species of mold on the surface of unsalted butter

Calcium propionate (per cent)	pH	Amount of growth after							
		8 days	10 days	12 days	14 days	16 days	18 days	20 days	24 days
					Hormodendrum cladosporioides				
10	8.3	3–	3–	3–	3–	3–	3–	1–2++	3++
10	5.5	3–	3–	3–	3–	3–	1–2+	1–2++	1–2++
5	7.9	3–	3–	3–	3–	1–2+	3+	3+	3++
5	5.5	3–	3–	3–	3–	3–	3–	3–	3–
5	4.5	3–	3–	3–	3–	3–	3–	3–	3–
Control	.....	3–	3–	3+	3++	3++++	3++++	3++++	3++++
					Cladosporium species				
10	8.3	3–	3–	3–	3–	3+	Discarded	.....	.....
10	5.5	3–	3–	3–	3–	3–	3–	3–	2–1+
5	7.9	3–	3–	3–	2–1+	3+	Discarded	.....	.....
5	5.5	3–	3–	3–	3–	3–	3–	3+	3+
5	4.5	3–	3–	3–	3–	3–	3–	3–	3–
Control	.....	3–	3++	3+++	3++++	Discarded	.....	.....	.....
					Stemphylium congestum				
10	8.3	3–	3–	3–	3–	3–	2–1+	3++	3+++
10	5.5	3–	3–	3–	3–	3–	2–1+	1–2++	3++
5	7.9	3–	3–	3–	3+	3++	Discarded	.....	.....
5	5.5	3–	3–	3–	3–	3–	2–1+	3+	3+
5	4.5	3–	3–	3–	3–	3–	3–	2–1+	2–1+
Control	.....	3–	3–	3+	3+	3++	Discarded	.....	.....
					Penicillium expansum				
10	8.3	3–	3–	3–	3+	3++	Discarded	.....	.....
10	5.5	3–	3–	3–	3+	3++	Discarded	.....	.....
5	7.9	3–	3+	3+	3+	3++	Discarded	.....	.....
5	5.5	3–	3–	3–	3+	3++	Discarded	.....	.....
5	4.5	3–	3–	3–	3+	3++	Discarded	.....	.....
Control	.....	3–	3+	3++	3++	3++	Discarded	.....	.....
					*Aspergillus niger**				
10	8.3	3–	3–	3–	3–	3–	3–	3–	3–
10	5.5	3–	3–	3–	3–	3–	3–	3+	3+
5	7.9	3–	3–	3–	1–2+	3+	3+	3+	3+
5	5.5	3–	3–	3–	3–	3–	Not examined	1–2+	1–2+
5	4.5	3–	3–	3–	3–	3–	Not examined	3+	3+
Control	.....	3–	2–1+	3+	3+	3+	3+	3+	3+

Note: – = No visible growth.
+ = Scanty growth.
++ = Moderate growth.
+++ = Abundant growth.
++++ = Luxuriant growth.

The number followed by symbols may be interpreted for example as follows: 3+ means that all three of the samples showed scanty growth; 2–1+ means two samples showed no growth while one showed scanty growth.

* All growth consisted of very scant white mycelium which was evident only on very close examination.

inhibiting surface mold growth when used for wrapping butter. Figures 1 and 2 show representative prints from these trials. From figure 1 it is quite apparent that "Mycoban" impregnated paper offered little protection when treated in water before use. Under such treatment the propionate leaches from the paper rapidly, leaving an insufficient concentration to subsequently inhibit growth. The storage temperature in this case was five to ten degrees higher than in other trials and growth appeared more rapidly.

Figure 2 shows the effectiveness of either the ten per cent or acidified five

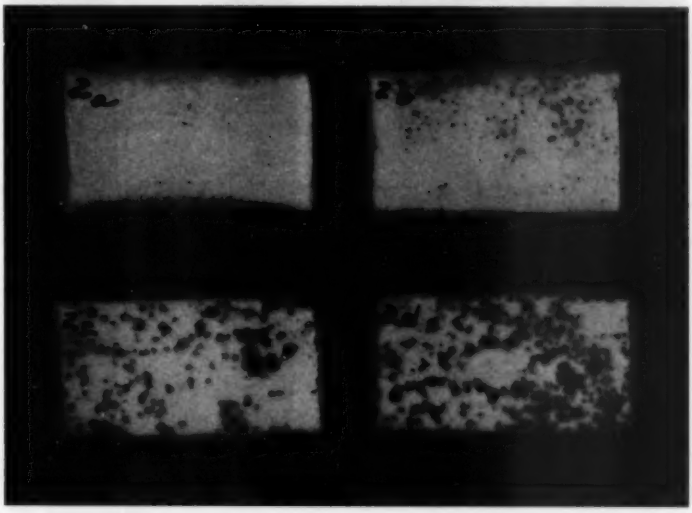

FIG. 1. This photograph shows the appearance after one week storage at 50–55° F. of representative prints of unsalted butter sprayed with a mixed mold spore suspension and wrapped with "Mycoban" impregnated parchment; (2a) wrapped with dry "Mycoban" impregnated paper; (2b) wrapped with "Mycoban" impregnated paper dipped in water before wrapping; (2c) and (2d) wrapped with "Mycoban" impregnated paper immersed in water for two and five minutes respectively before wrapping.

per cent calcium-propionate-treated parchment. The wetted Mycoban and "X" impregnated parchments provided little protection; in fact, after ten days storage these prints showed abundant visible mold growth.

II

One of the criteria for the use of any substance as a mold inhibitor for butter should be that it cause little or no deleterious effect on flavor. The effect of sodium-propionate-, calcium-propionate- and acidified calcium-propionate-treated wrappers on the surface flavor of butter was determined.

One-eighth-pound prints of 93-score unsalted butter, two for each solu-

tion and for each period of observation, were wrapped with parchment immersed in various solutions of sodium propionate and calcium propionate. The prints were examined after one day, one week, two weeks and three weeks storage in a commercial storage butter room. The storage temperature varied from 39° to 48° F. A Federal butter judge examined all prints and his observations are recorded in table 2. Only the surface of the butter

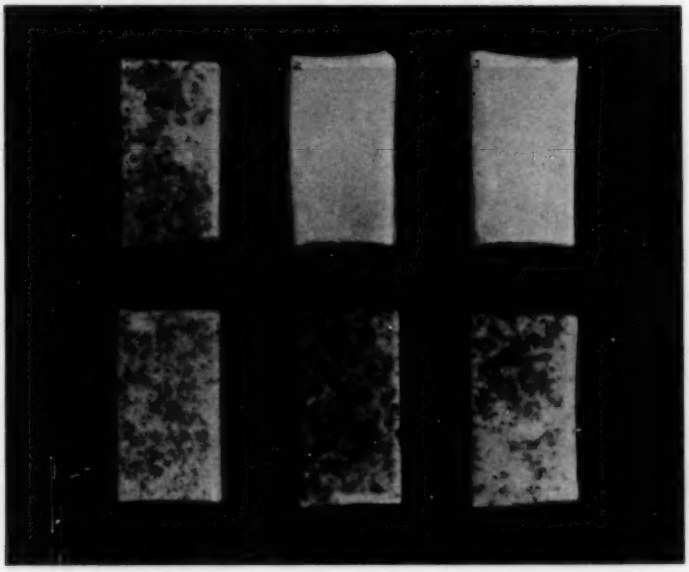

FIG. 2. This photograph shows the appearance after eighteen days storage at 45° F. of representative prints of unsalted butter sprayed with a spore suspension of *H. cladosporioides* and wrapped with parchment as follows: (1) control—non-treated parchment immersed in sterile water, (2) parchment immersed in ten per cent calcium propionate solution, (3) parchment immersed in five per cent calcium propionate solution acidified to pH 5.5, (4) "Mycoban" impregnated parchment immersed in sterile water for five minutes before wrapping, (5) one per cent "X" impregnated parchment immersed in sterile water for five minutes before wrapping, (6) five per cent "X" impregnated parchment immersed in sterile water for five minutes before wrapping.

was judged. Throughout the entire storage period, butter wrapped with parchment treated in the five per cent acidified calcium propionate solution showed the least change in flavor. These prints were very similar to the controls after one week; however, after two weeks the superiority in flavor over the controls was striking. No mold was evident and the characteristic old or aged flavor which was so prevalent in the control prints was entirely absent. After three weeks, a slight aged flavor was noted.

The butter wrapped in parchments treated in the other calcium pro-

pionate solutions all showed a bitter flavor which was noticed immediately on tasting but dissipated rapidly, yet a puckery sensation lingered. This bitterness and puckery effect diminished as the storage period advanced.

The butter wrapped in parchment treated in the sodium propionate solutions all possessed a sweetish flavor very similar to that of neutralized sweet

TABLE 2

The surface flavor of unsalted butter after wrapping with parchment treated in solutions of sodium propionate and calcium propionate after storage at 39°–48° F.

Description of solutions	Comments after one day
10% Na propionate	Slight sweet and bitter. Not objectionable.
12% Na propionate	" " " " " "
14% Na propionate	" " " " " "
10% Ca propionate	" " " " " "
12% Ca propionate	" " " " " "
14% Ca propionate	Objectionable bitter taste.
*5% Ca propionate	Very slight bitter. Not objectionable. Very similar to control.
Control	No change.
	Comments after one week
10% Na propionate	Same as after one day.
12% Na propionate	" " " " "
14% Na propionate	" " " " "
10% Ca propionate	" " " " "
12% Ca propionate	" " " " "
14% Ca propionate	" " " " "
*5% Ca propionate	" " " " "
Control	No change.
	Comments after two weeks
10% Na propionate	Definitely aged.
12% Na propionate	Sweet flavor similar to neutralized sweet cream. Objectionable.
14% Na propionate	" " " " " " " "
10% Ca propionate	Same as after one day.
12% Ca propionate	Bitter. Objectionable.
14% Ca propionate	" "
*5% Ca propionate	Same as after one day.
Control	Moldy and definitely aged.
	Comments after three weeks
10% Na propionate	Definitely aged.
12% Na propionate	Same as after two weeks. Slight age.
14% Na propionate	" " " " " " "
10% Ca propionate	Slight bitterness. Slight age. Not objectionable.
12% Ca propionate	Bitterness less intense than after two weeks.
14% Ca propionate	" " " " " " "
*5% Ca propionate	Very slight age.
Control	Moldy and definitely aged.

* The five per cent calcium propionate solution was acidified to pH 5.5 with lactic acid.

cream. This flavor appeared to increase in intensity with storage. The butter wrapped with the ten per cent sodium-propionate-treated wrappers showed age at two weeks and possessed the poorest flavor of any after two and three weeks storage.

DISCUSSION

The results of other trials made to determine the effectiveness of sodium chloride–sodium propionate and sodium chloride–calcium propionate solutions, showed little advantage in using a mixture of the two salts over the straight sodium chloride solution when salted butter was wrapped. The use of either propionate, however, was more effective in inhibiting mold growth than a saturated sodium chloride solution.

Studies were also made to determine protection provided by propionate-treated wrappers for butter pre-stored at – 10° F. for one, two and three months, and subsequently held at 40°–50° F. The effect of low-temperature pre-storage did not prevent subsequent protection from mold growth on storage at high temperature.

With respect to the flavor studies presented, unsalted butter wrapped in parchment treated in a five per cent calcium propionate solution at pH 5.5 showed marked superiority in keeping quality, as judged by surface flavor, than controls or other prints wrapped in parchments treated in unacidified solutions of higher concentration. All controls showed mold growth and flavor deterioration after two weeks. The butter was not artificially infected, but was from a fresh 93-score commercial lot, graded under the Federal grading system and printed immediately after grading. The prints were selected at random within a few hours after grading. The results of this study clearly show the lack of proper methods of mold control by the manufacturer of that butter, as well as the effectiveness of calcium propionate on keeping quality.

The experimental conditions under which these investigations were made were extremely conducive to rapid mold growth. This was particularly true of humidity conditions. The question was raised early in this work as to why mold growth was not uniform over the entire surface of the prints wrapped in treated parchments. Mold development on the controls was uniformly present over the surface. In the majority of instances where the data indicate scanty growth, only one or two spots of mold was present. Further it was observed that not infrequently one or two of the prints would remain free of visible mold for a longer period than others of the same group and in some instances would remain mold-free for the entire period of observation. Perhaps such lack of uniformity of growth may be explained by the fact that quarter-pound prints were, (1) cut into eighths by hand which involved considerable handling, resulting in somewhat irregular surfaces and, (2), wrapped by hand which left much to be desired with respect to uniform contact between butter surface and parchment.

SUMMARY

1. Parchment paper treated in five per cent calcium propionate solution acidified to pH 5.5 with lactic acid was fully as effective in inhibiting mold

growth on unsalted butter as parchments treated in ten per cent unacidified solution. Further, butter wrapped in parchments treated in the five per cent acidified solution showed marked superiority in keeping quality, as judged by surface flavor over controls or other prints wrapped in parchments treated in unacidified solutions of higher concentration.

2. No advantage was obtained by using a solution consisting of a mixture of either propionate with sodium chloride for the treatment of wrappers. Solutions of either propionate were superior to a saturated solution of sodium chloride for the inhibition of surface mold growth.

3. Below 0° F. pre-storage of butter, wrapped in propionate-treated parchment, did not prevent subsequent protection against mold growth on storage at higher temperatures.

4. Calcium-propionate-impregnated parchments were found to be effective only when used in dry wrapping. Immersing such paper in water before wrapping resulted in leaching the propionate from the paper and consequently a loss of effectiveness.

5. Heating acidified or unacidified propionate solutions did not impair their effectiveness.

6. The species of Penicillium used was markedly more resistant to the inhibiting effect of the propionates than species of other genera studied.

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THE DETERMINATION OF TOTAL SOLIDS IN DAIRY PRODUCTS BY DRYING WITH FORCED HEATED AIR. I. RESULTS WITH MILK, SKIM MILK, CREAM, CONDENSED MILK, CONDENSED SKIM MILK AND EVAPORATED MILK*

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It is generally conceded that moisture determinations in biological materials must follow empirical procedures and this viewpoint is confirmed by Halvorson (1), who in 1937 published a thorough survey of methods recognized by the Association of Official Agricultural Chemists. He concluded that it is not possible to arrive at the absolute water content of agricultural products and that the only practical method of determining total solids or moisture is to define them in terms of the residue or loss resulting from drying the materials under definitely specified conditions of temperature, time, pressure and any other factors which influence the rate or degree of moisture loss.

The Mojonnier methods (3) based on A.O.A.C. definitions (2) of total solids are generally accepted as satisfactory by the dairy industry. Not all laboratories can justify the cost of Mojonnier testers, however, and are forced to use the slower "Official Methods" or the less accurate indirect methods employing hydrometers. Moreover, in cases where only one or two samples are to be analyzed the Mojonnier tests can hardly be called convenient inasmuch as considerable time is required for bringing the hot plates to the required temperatures. Thus, there is a need for a quick, accurate and inexpensive method for determining the total solids in dairy products, especially where only one or two samples are analyzed at one time.

An instrument known as the "Dietert Moisture Teller," originally designed for determining the moisture content of sand; coke, gravel, cinders, etc., has been found satisfactory for agricultural roughages (4, 5) and appeared to offer possibilities for the estimation of total solids in fluid dairy products. Consequently, its use for this purpose was subjected to detailed study and the results constitute the basis for this report.

THE "DIETERT MOISTURE TELLER" AND ITS USE

Briefly, the "Dietert Moisture Teller," illustrated in figure 1, consists of an electric blower and heating element encased in the upper portion of a tube which terminates at the bottom in a flared enlargement. A removable pan (dishholder), the bottom of which is constructed of fine woven brass

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screening, is held snugly against the flared end of the tube by means of a spring clamp. The tube contains an air diffuser and a thermometer located immediately over the pan. At the top of the upright panel, to which the mechanism is attached, an automatic timing dial and switch are placed. The dial is graduated in half-minute intervals from zero to 15. Thirty- and 60-minute timers are also available. A thermo-regulator is attached to the flared base of the tube at the right side and just above the pan. Temperature adjustments are made by merely turning a knurled knob.

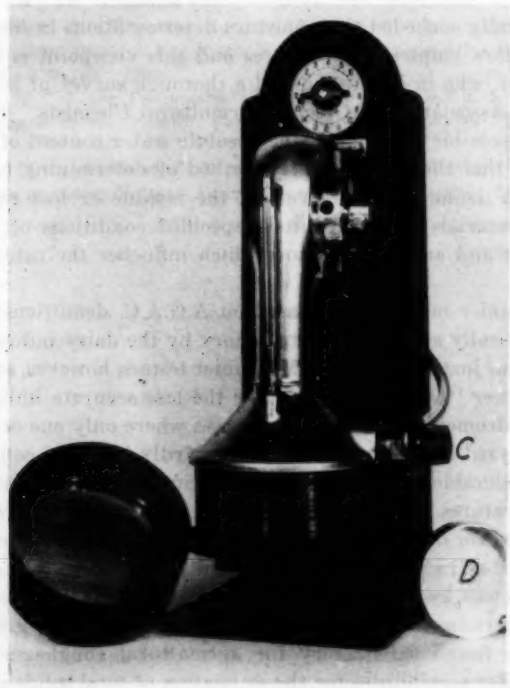

FIG. 1. The Dietert Moisture Teller: A, dishholder; B, interval timer and switch; C, thermo-regulator; D, total solids dish. The instrument is manufactured by the H. W. Dietert Company, 9330 Roselawn Avenue, Detroit, Michigan.

In using the Dietert apparatus for drying samples of fluid dairy products for the purpose of determining the total solids, suitable sample dishes (Mojonnier solids dishes are satisfactory), a laboratory desiccator of proper size, and an analytical balance are required. All precautions in the weighing of samples and residues and in the handling and cooling of dishes, etc., customarily required in quantitative analysis must be observed.

Preliminary adjustments of the thermo-regulator should be made. The

apparatus is then turned on by moving the timing pointer past three on the dial. This starts the blower and sends current through the heating elements. When the thermometer shows that the air temperature has reached the desired point, the pan containing the centered dish (tared) and well-spread sample is inserted in the clamp ring. Then the timer is set for the interval of drying desired. The draft of heated air is directed evenly onto the sample, rapidly evaporating the moisture and carrying it out through the screen base of the pan or dishholder. When the set time has elapsed the blower and heat are automatically cut off. At this point the dish containing the dried residue from the sample should be promptly removed to a desiccator and allowed to cool to balance temperature for accurate subsequent weighing.

METHODS AND PROCEDURE

Preliminary observations revealed that the "Dietert Moisture Teller" was capable of rapidly removing moisture from dairy products and producing an apparently dry residue. Three different units when operated at the same temperatures and time intervals gave closely agreeing weights of residues from various fluid dairy products when all variables were controlled.

Efforts to use comparatively large samples and less expensive balances of the torsion type failed to give consistent results and it was found necessary to use an analytical balance with careful adherence to recognized analytical practices in weighing the dishes, samples and residues.

The possibility of using smaller sample dishes and drying duplicate or triplicate samples in the apparatus simultaneously was thoroughly investigated but erratic results were obtained. This, however, does not preclude the probability that satisfactory multiple drying units can be constructed utilizing the principle of forced, heated air.

After preliminary work had shown the capabilities of the Dietert apparatus and had narrowed down the number of the variables, some of which are mentioned above, it was deemed necessary to study each product separately in order to determine the most suitable time and temperature of drying, the best quantity of sample, whether dilution of the sample is advantageous, the proper diameter of dish, etc. To do this, a large number of determinations were made, varying one factor at a time and comparing results with the average of triplicate determinations made according to "Official Methods." Scrupulous care was exercised in all of the work to avoid any fortuitous influences and to assure that the results represented only the effect of the variable under consideration.

Seven samples of milk varying in fat content from 3.7 per cent to 4.4 per cent were analyzed for total solids in triplicate using the method given in the Fifth Edition of "Official and Tentative Methods of Analysis" (2) including the use of sand (optional) and an aluminum dish 75 mm. in diameter. These samples were then analyzed in triplicate by means of the "Dietert

Moisture Teller," using 16 different combinations of drying intervals (10 to 25 minutes) and temperatures (100° to 125° C.) and employing both one- and two-gram samples. The results were compared with the average of those obtained by the "Official Method." After a suitable temperature and drying interval had been selected for use with the Dietert apparatus three additional samples of milk were analyzed using triplicate dishes having diameters of 50, 65, 75, 90, 95 and 100 mm., respectively.

Substantially the same method was utilized for verifying a satisfactory Dietert procedure for determining the total solids of fluid skim milk, light and heavy cream and plain condensed whole and skim milk using between 6 and 12 samples for each product and omitting the 100° C. temperature. In the case of the concentrated products the Dietert samples consisted of (a) one gram of product plus one ml. of water, (b) two grams of product and (c) two grams of the product diluted as required in "Official Methods" for evaporated milk.

Following the establishment of what was considered a suitable Dietert procedure a limited number of samples of each of the products were analyzed in triplicate using this procedure and the results compared with the average of triplicate determinations made by "Official Methods." For comparative purposes they were also analyzed in triplicate by the Mojonnier Method.

The preliminary study using dishes of different diameters indicated that the 75-mm. dish gave more satisfactory results with most of the products and at least as satisfactory with all products than dishes of any other size.

RESULTS

Milk

Observations made on the drying of milk samples with the Dietert Moisture Teller indicated that fairly satisfactory total solids results could be obtained with either a one-gram or a two-gram sample and at high temperatures for shorter drying periods or at low temperatures for longer intervals. Analysis revealed, however, that while average results might be similar, the larger sample and longer drying intervals gave more uniform and closely agreeing results. On the basis of this study the following procedure was deemed the most satisfactory of those tried and is suggested for use with the "Dietert Moisture Teller."

Procedure for milk. A flat-bottom dish of 75 mm. diameter is heated in the Dietert apparatus for at least 10 minutes during which time the temperature of the apparatus is checked and adjusted. It is cooled in a desiccator to balance temperature and weighed, with a suitable cover, using an analytical balance. Approximately two grams of well-mixed milk are then put into the dish and accurately and quickly weighed (weighing pipettes may be used). The milk is spread evenly over the dish and it is placed in

the center of the pan of the operating Dietert apparatus in a level position. The temperature should again be checked and drying should be carried out for 20 minutes at 120° C. When drying is completed, the dish should be immediately transferred to a laboratory desiccator until cool. It is then weighed, with cover, and the weight of dry residue expressed as per cent of total solids.

Confirmation of accuracy. Total solids were determined in triplicate in five samples of milk using the above procedure and also the Mojonnier Method. The results were compared with the average results of triplicate

TABLE 1

Accuracy of the selected Dietert procedure for determining total solids of fluid whole milk as judged by the results obtained with the "Official Method" and as compared with those found by the Mojonnier method

Per cent T.S. "Official"	Results with Dietert apparatus		Results with Mojonnier tester	
	Per cent T.S.	Variation from "Official"	Per cent T.S.	Variation from "Official"
12.32	12.38	+0.06	12.38	+0.06
	12.44	+0.12	12.35	+0.03
	12.34	+0.02	12.36	+0.04
12.69	12.82	+0.13	12.73	+0.04
	12.84	+0.15	12.76	+0.07
	12.77	+0.08	12.71	+0.02
12.75	12.77	+0.02	12.87	+0.12
	12.74	−0.01	12.87	+0.12
	12.71	−0.04	12.91	+0.16
12.80	12.80	0.00	12.76	−0.04
	12.75	−0.05	12.81	+0.01
	12.78	−0.02	12.79	−0.01
12.75	12.84	+0.09	12.77	+0.02
	12.83	+0.08	12.71	−0.04
	12.77	+0.02	12.67	−0.08
Algebraic average		+0.043		+0.036
Arithmetical average		±0.059		±0.057
Range		−0.05 to +0.15		−0.08 to +0.16

determinations by the "Official Method." The comparative data are shown in table 1. It appears that the Dietert apparatus is capable of giving total solids results, with milk, which closely parallel the accuracy of the Mojonnier Method. This accuracy is considered highly satisfactory.

Skim Milk

The experience with fluid skim milk in varying the time and temperature of Dietert drying, the size of sample and size of dish was practically identical with that of fluid whole milk. Consequently, the same procedure was selected as being best suited to this product. Table 2 shows the comparative accuracy attained employing the Dietert apparatus and the Mojonnier tester with five samples of fluid skim milk.

TABLE 2

Accuracy of the selected Dietert procedure for determining total solids of fluid skim milk as judged by the results obtained with the "Official Method" and as compared with those found by the Mojonnier method

Per cent T.S. "Official"	Results with Dietert apparatus		Results with Mojonnier tester	
	Per cent T.S.	Variation from "Official"	Per cent T.S.	Variation from "Official"
9.10	9.13	+0.03	9.16	+0.06
	9.15	+0.05	9.18	+0.08
	9.09	−0.01	9.15	+0.05
8.96	Lost	.....	8.98	+0.02
	9.03	+0.07	8.99	+0.03
	9.01	+0.05	8.98	+0.02
9.10	9.19	+0.09	9.13	+0.03
	9.21	+0.11	9.12	+0.02
	9.18	+0.08	9.11	+0.01
9.18	9.27	+0.09	9.24	+0.06
	9.25	+0.07	9.24	+0.06
	9.25	+0.07	9.24	+0.06
9.14	9.19	+0.05	9.10	−0.04
	9.21	+0.07	9.13	−0.01
	9.20	+0.06	9.11	−0.03
Algebraic average		+0.063		+0.028
Arithmetical average		±0.064		±0.039
Range		−0.01 to +0.11		−0.04 to +0.08

Cream

Cream samples were found to be somewhat more difficult to dry than milk and skim milk samples. This was true even of the Official method. The

TABLE 3

Accuracy of the selected Dietert procedure for determining total solids of light cream as judged by the results obtained with the "Official Method" and as compared with those found by the Mojonnier method

Per cent T.S. "Official"	Results with Dietert apparatus		Results with Mojonnier tester	
	Per cent T.S.	Variation from "Official"	Per cent T.S.	Variation from "Official"
28.06	28.06	0.00	28.02	−0.04
	28.10	+0.04	28.05	−0.01
	28.03	−0.03	Lost	.....
25.96	26.11	+0.15	26.14	+0.18
	25.97	+0.01	26.08	+0.12
	Lost	.....	25.96	0.00
26.08	26.23	+0.15	26.16	+0.08
	26.12	+0.04	26.16	+0.08
	26.05	−0.03	25.87	−0.21
27.27	27.21	−0.06	27.33	+0.06
	27.49	+0.22	Lost	.....
	27.18	−0.09	27.43	+0.16
Algebraic average		+0.036		+0.042
Arithmetical average		±0.075		±0.094
Range		−0.09 to +0.22		−0.21 to +0.18

study of variables with both light cream (18.0 to 20.5 per cent fat) and heavy cream (37.0 to 43.5 per cent fat) indicated that the total solids results agreed more satisfactorily with those obtained with the "Official Method" when a two-gram sample was dried in the Dietert apparatus at 120° C. for 25 minutes using a 75-mm. dish. Consequently, this procedure is recommended for all cream samples. Table 3 illustrates the experience with four samples of light cream tested by the Dietert and Mojonnier Methods and table 4 presents similar data covering five samples of heavy cream. The total solids results obtained with the Dietert Method are just as accurate, on the whole, as with the Mojonnier for light and heavy cream.

TABLE 4

Accuracy of the selected Dietert procedure for determining total solids of heavy cream as judged by the results obtained with the "Official Method" and as compared with those found by the Mojonnier method

Per cent T.S. "Official"	Results with Dietert apparatus		Results with Mojonnier tester	
	Per cent T.S.	Variation from "Official"	Per cent T.S.	Variation from "Official"
41.63	42.13	+0.50	41.63	0.00
	41.96	+0.33	41.83	+0.20
	41.60	−0.03	41.75	+0.12
46.94	47.10	+0.16	47.16	+0.22
	47.02	+0.08	47.19	+0.25
	47.02	+0.08	47.08	+0.14
43.06	43.08	+0.02	43.27	+0.21
	43.04	−0.02	43.19	+0.13
	43.02	−0.04	43.31	+0.25
42.31	42.39	+0.08	42.46	+0.15
	42.37	+0.06	42.46	+0.15
	42.32	+0.01	42.41	+0.10
47.80	47.92	+0.12	48.05	+0.25
	47.82	+0.02	47.95	+0.15
	47.79	−0.01	47.91	+0.11
Algebraic average		+0.091		+0.162
Arithmetical average		±0.104		±0.162
Range		−0.04 to +0.50		0.00 to +0.25

Condensed Milk, Condensed Skim Milk and Evaporated Milk

Inasmuch as the results obtained with milk and cream indicated that temperatures under 120° C. were unsatisfactory for drying with the Dietert apparatus and since concentrated milks are known to dry less readily, the study of variables was limited to temperatures of 120° C. and above with these products. The "Official Method" used was that recommended for evaporated milk and Dietert samples consisted of (a) one gram of the product plus one ml. of water, (b) two grams of the product and (c) two grams of the product diluted as prescribed in "Official Methods." The results indicated that all these products responded best to the same conditions of drying. The recommended procedure is to dry one gram of the product diluted with

TABLE 5

Accuracy of the selected Dietert procedure for determining total solids of condensed milk, condensed skim milk and evaporated milk as judged by the results obtained with the "Official Method" (evaporated milk) and as compared with those found by the Mojonnier method

Per cent T.S. "Official"	Results with Dietert apparatus		Per cent T.S. "Official"	Results with Mojonnier tester	
	Per cent T.S.	Variation from "Official"		Per cent T.S.	Variation from "Official"
Condensed milk					
45.12	45.24	+0.12	36.06	36.18	+0.12
	45.30	+0.18		36.39	+0.33
				36.07	+0.01
43.22	43.31	+0.09	44.76	44.90	+0.14
	43.14	−0.08		44.95	+0.19
				44.59	−0.17
45.12	45.16	+0.04	43.22	43.39	+0.17
	45.26	+0.14		43.52	+0.30
Algebraic average		+0.095			+0.157
Arithmetical average		±0.108			±0.179
Range		−0.08 to +0.18			−0.17 to +0.30
Condensed skim milk					
28.91	29.04	+0.13	28.58	28.66	+0.08
	28.93	−0.02		28.71	+0.13
	29.03	+0.12		28.84	+0.26
28.30	28.55	+0.25	27.09	27.14	+0.05
	28.41	+0.11		27.08	−0.01
	28.07	−0.23		27.14	+0.05
28.30	28.51	+0.21	27.07	27.26	+0.19
	28.53	+0.23		27.19	+0.12
	28.50	+0.20			
27.93	27.67	−0.26	27.74	27.98	+0.24
	27.78	−0.15		27.85	+0.11
	27.85	−0.08		27.81	+0.07
Algebraic average		+0.104			+0.118
Arithmetical average		±0.166			±0.119
Range		−0.26 to +0.25			−0.01 to +0.26
Evaporated milk					
26.18	26.22	+0.04	26.18	26.11	−0.07
	26.16	−0.02		26.14	−0.04
	26.10	−0.08		26.18	0.00
26.05	26.03	−0.02	26.05	26.14	+0.09
	26.05	0.00		26.13	+0.08
	26.12	+0.07		26.17	+0.12
26.00	26.01	+0.01	26.00	26.09	+0.09
	26.03	+0.03		26.18	+0.18
	26.00	0.00		26.08	+0.08
26.14	26.13	−0.01	26.14	26.09	−0.05
	26.08	−0.06		26.07	−0.07
	26.08	−0.06		26.05	−0.09
26.09	26.08	−0.01	26.09	26.07	−0.02
	26.15	+0.06		26.04	−0.05
	26.12	+0.03		26.07	−0.02
Algebraic average		−0.017			+0.037
Arithmetical average		±0.033			±0.064
Range		−0.08 to +0.07			−0.09 to +0.12

one ml. of water, for 25 minutes at 120° C. Results obtained with several samples of each of the three products are shown in table 5.

It is obvious from these data that the Dietert procedure for determining total solids in concentrated fluid dairy products gives results which are just as accurate as those obtainable with the Mojonnier tester and in reasonably good agreement with "Official Methods."

Effect of Clogging of Screen of Dishholder

The dishholder of the Dietert apparatus has a fine woven screen bottom through which the moisture-laden, hot air leaves the assembly. At one stage in the analytical work it was noted that total solids results were abnormally high and tended to become higher in additional trials. Examination revealed

TABLE 6

Effect of clogging of the screen of the dishholder of the Dietert apparatus on analytical results

Product analyzed	Condition of dish-holder	Average algebraic per cent variation in total solids from "Official" when dried at				
		110° C.	120° C.	130° C.	140° C.	150° C.
Condensed skim milk	Dirty	+3.25	+1.40	+1.04	+0.54	.....
	Clean	+0.30	+0.05	−0.32	−0.82	.....
Fluid milk	Dirty	+4.22	+1.39	+0.43	+0.14	.....
	Clean	+0.39	+0.07	+0.02	−0.16	.....
Condensed whole milk	Dirty	.....	+0.74	+0.41	.....	.....
	Clean	+0.27	−0.14	.....	.....	.....
Sweetened condensed whole milk	Dirty	.....	.....	.....	.....	+1.48
	Clean	.....	.....	.....	.....	−0.03

that the dishholder screens had become clogged with what appeared to be fine carbon from the motor brushes. When this was discovered a comparison of results obtained on several products using the dirty dishholders and new unused dishholders was made. A portion of these are included in table 6. These data indicate that the clogged screens caused a diminution of the amount of air passing through the apparatus, restricting evaporation and resulting in incomplete drying of the samples.

It was found necessary to clean the dishholders frequently and thoroughly. Their condition can readily be ascertained by viewing them before a strong light.

CONCLUSIONS

Evidence has been presented showing that the "Dietert Moisture Teller," a drying apparatus employing forced, heated air, can be used conveniently in the determination of total solids in fluid whole milk, fluid skim milk, light and heavy cream, condensed whole milk, condensed skim milk and evaporated milk.

Results having as high a degree of accuracy as the Mojonnier tester are obtainable with the Dietert apparatus when fluid milk samples are dried at 120° C. for 20 minutes and when cream and the afore-mentioned concentrated milk products are dried at the same temperature for 25 minutes.

A single solids determination can be completed within one hour with the "Dietert Moisture Teller." With the Mojonnier tester this will require about 35 minutes provided the oven and plate are at the required temperature, otherwise, somewhat more than one hour will be needed. A determination by "Official Methods" will take from three to four hours, depending on the product and on the alternative method selected.

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ABSTRACTS OF LITERATURE

BOOK REVIEW

280. Advances in Enzymology and Related Subjects of Biochemistry. Vol. V. F. F. NORD AND C. H. WERKMAN, Editors. Interscience Publishers, Inc., 215 Fourth Ave., New York 3, N. Y. 268 pages, 8 chapters, author, subject and 5-volume cumulative index, $5.50.

This, the fifth volume, is a continuation of an excellent series on enzymology consisting of reviews and discussions by authorities on the subjects. The eight chapters cover the physical and chemical properties of tomato bushy stunt virus and the strains of tobacco mosaic virus; the coagulation of blood; amino acid decarboxylases of mammalian tissues, alcoholic fermentation of the oligosaccharides, pyruvate metabolism, biochemistry of fusaria, enzymatic reactions of nocotinamide, and of sulfur compounds. This volume and others of the series are tools principally of the research work in biochemistry. K.G.W.

281. The Semen of Animals and Its Use for Artificial Insemination. JAMES ANDERSON, Experiment Station, Naivasha, Kenya. Imperial Bureau of Animal Breeding and Genetics Technical Communication, Edinburgh. 151 pp., 19 fig. April, 1945.

Two exceedingly useful reviews on artificial insemination and its related problems have been published by the Imperial Bureau of Animal Breeding and Genetics in Edinburgh, Scotland. The first, by Arthur Walton, was published in 1933. It served to introduce this subject to many readers in the English-speaking nations, and it constituted the first important source of information concerning the work of the numerous Russian scientists who had contributed to this field. The second of these reviews has only recently appeared. This one, by Dr. James Anderson of the Experimental Station, Naivasha, Kenya, is fully as useful as the first one mentioned and is a *must* for every worker in this field, whether he be in research or primarily concerned in the practical application of artificial insemination.

Dr. Anderson has cited a major portion of the literature concerning artificial insemination of cattle, sheep, horses, swine, rabbits, dogs, foxes and poultry. Major emphasis is given to the first four species. The first part constituting 99 pp. deals with the characteristics of the semen of the several species, factors affecting semen production, the physico-chemical properties of semen, the physiology of spermatozoa, semen storage and transport, and the examination of semen. A much shorter Part II deals with the advantages and uses of artificial insemination, growth of the practice in various countries and factors influencing its success. Part III gives a step by step

discussion of procedure in the practical use of artificial insemination ending with a brief statement on the management of sires. A supplement containing papers which appeared after the main body of the report was completed is included. In this section the headings used are identical with that of the report.

Dr. Anderson has attempted to compile a fairly complete list of the published work and observations on this subject. He makes no attempt to present the material in temporal sequence but rather presents the information by subject matter. His report includes the basic Russian work which founded the techniques and brings one as closely up to date as can be done by any such review. Emphasis is placed on the Russian, British, and American publications. His main sources of reference to the Russian literature are apparently the same abstract journals as are available to other English-speaking investigators so this report does not constitute the critical analysis of Russian work which is so badly needed.

The material presented appears to be taken largely from the conclusions of the various authors cited. Facts and figures are given where possible but apparently no attempt has been made to critically review the nearly 600 papers listed in the bibliography. Nevertheless, the review will be found exceedingly useful by workers in this field for it constitutes the best source of reference on the subject yet published in English. The publishers and the author are to be commended for their effort. G.W.S.

BACTERIOLOGY

282. Heat Activation Inducing Germination in the Spores of Thermotolerant and Thermophilic Aerobic Bacteria. HAROLD R. CURRAN AND FRED R. EVANS, Dairy Res. Lab., Bur. of Dairy Ind., U.S.D.A. Jour. Bact., *49*, No. 4: 335. April, 1945.

This is an account of a detailed study involving (1) Activation of spores in relation to the amount of heat applied, (2) Activation of spores as influenced by the nature of the heating medium and by the temperature of subcultivation, (3) The temperature at which spores are formed in relation to heat activation, (4) Pasteurization in relation to heat activation, and (5) Persistence of heat activation.

It is concluded that heat activation of spores contributes to the spoilage of certain types of canned foods. However, in the manufacture of evaporated milk, the forewarming of raw milk at 95° C. for 10 minutes prior to its condensation results in the heat activation of spores, so that a large proportion are killed by the subsequent processing treatment.

A study of 12 thermotolerant cultures isolated from 10 outbreaks of spoilage in commercially processed evaporated milk revealed that nearly all would respond to pregermination heating. At 95° C. in skim milk the heat-

activating process was nearly complete in 10 minutes and entirely so in 30 minutes. Long-hold pasteurization effects material activation of spores.
D.P.G.

283. The Destruction of Thermophilic Bacteria by Ultraviolet Rays. LOUIS LANG, Natl. Sugar Refining Co. Jour. Bact., *49*, No. 4: 414. April, 1945. Proc. of Local Branches.

Equipment and process are described for freeing sugar of thermophiles by exposing it to ultraviolet light while being transported on conveyors. Approximately one ton of sugar per hour meeting the National Canners' specifications is produced. D.P.G.

284. Penicillin as a Food Preservative. ANONYMOUS. Jour. Amer. Med. Assn., *128*, No. 8: 596. June 23, 1945.

Attention is called to the work of Curran and Evans, of the U.S.D.A., Division of Dairy Research, in which they have tested the efficacy of penicillin as a food preservative (sporicide) in foods that are pasteurized, leaving residual, viable spores. In one test, five Oxford units of penicillin per cc. produced a reduction of *Bacillus subtilis* spores from 256 per cc. to 1.6 per cc. at the end of five hours and to 0.04 per cc. at the end of 27 hours. Curran has suggested the use of penicillin in numerous nonmedical fields, including that of food preservation. Relatively inexpensive crude penicillin presumably would be satisfactory for such uses. Reference is made to Proc. Soc. Expt. Biol. & Med., *58:* 262. March, 1945. D.P.G.

BUTTER

285. Building for the Future through Apprenticeship Training. ANONYMOUS. Natl. Butter and Cheese Jour., *36*, No. 7: 38. July, 1945.

The apprenticeship training program for buttermakers is now in operation in Wisconsin (see Jour. Dairy Sci., Abstracts of Literature, *28*, No. 5: A 72. May, 1945). The Veterans Administration is paying veterans $50 per month while in approved training; this amount is in addition to the wages paid the apprentice by the employer. A practical example is given to show how the program is working. W.V.P.

286. The Butter Situation. H. A. RUEHE, Amer. Butter Inst., Chicago, Ill. Natl. Butter and Cheese Jour., *36*, No. 7: 36. July, 1945.

The price established for butter is too low to permit it to compete successfully for butterfat. Farmers have been encouraged to sell whole milk instead of cream. From 1941 to 1944, 400 butter-making plants closed in the leading butter states. The Over-all Butter Industry Committee on

January 24, 1945, recommended: that the base price of butter be raised 6 cents per pound; that the subsidy on fat sold in cream be adjusted to equal at least one-fourth of the production payment for 100 pounds of whole milk; and that limitation orders be extended to cover all sales of factory-separated cream. The second recommendation was embodied in the Andresen amendment to Senate Bill 298 which was adopted. Increasing the ceilings on fat in cream would give cream producers returns comparable to whole milk producers and would increase their production of butterfat and, therefore, the amount of butter without interfering with supplies of other dairy products.

W.V.P.

CHEESE

287. A Phosphatase Test for Cheddar Cheese. GEORGE P. SANDERS AND OSCAR S. SAGER, Dairy Res. Lab., U. S. Dept. of Agr., Washington, D. C. Natl. Butter and Cheese Jour., *36*, No. 7: 42. July, 1945.

This preliminary report gives details of preparing buffer and precipitant, butyl alcohol, BQC solution, disodium phenyl phosphate substrate, and phenol standards for making the laboratory and field tests for phosphatase in cheese. Specific instructions and precautions are then given for conducting these tests.

More than 340 samples of Cheddar cheese were tested; all of those made from raw milk or under-pasteurized milk were positive, but those from pasteurized milk, regardless of age, gave no values greater than 5 units. Values of 8 to 10 units or more were regarded as indicating definite underpasteurization on cantamination with raw milk.

W.V.P.

CHEMISTRY

288. Determination of Vitamin C in the Presence of Interfering Reducing Substances. Selective Oxidation-Reduction Method. AUBREY P. STEWART, JR., AND PAUL F. SHARP, Res. Lab., Golden State Co., Ltd., San Francisco, Calif. Indus. Engin. Chem., Analyt. Ed., *17*, No. 6: 373–376. June, 1945.

Reduced ascorbic acid may be estimated in raw and pasteurized milk by acidifying the sample and titrating directly with a standardized solution of 2,6-dichlorophenol-indophenol. However, products such as dry and evaporated milk and sterilized canned fruits and vegetables may contain other reducing substances. The method described here provides for the determination of both reduced and dehydroascorbic acid as well as interfering reducing substances. Ascorbic acid and interfering reducing substances are first catalytically oxidized in the prepared samples by the addition of concentrated cucumber juice (ascorbic acid oxidase). The dehydroascorbic acid is specifically reduced to ascorbic acid by a suspension of *Escherichia coli* for dry or evaporated milk. *E. coli* or *Staphylococcus albus* was used

for fruit juices and *S. albus* for vegetable juices. The ascorbic acid thus formed is then determined by indophenol dye titration. The bacterial suspension reduces dehydroascorbic acid formed by the action of the oxidase on ascorbic acid, in addition to any dehydroascorbic acid present in the original sample, thus permitting a measure of total vitamin C. Results are given when the method was applied to reconstituted evaporated and dry milk, market milk, canned fruit and vegetable juices, urine and blood plasma.

B.H.W.

DISEASE

289. *Corynebacterium equi* in Chronic Pneumonia of the Calf. D. Frank Holtman, Univ. of Tenn. Jour. Bact., *49*, No. 2: 159. Feb., 1945.

Corynebacterium equi, commonly associated with pneumonia in foals and more recently with pulmonary lesions of swine, was isolated from purulent lesions in the lungs of a calf dead of chronic pneumonia of several months' duration. No other microorganism was found with it. It is suggested that the present name be changed, since the bacterium is infectious for other animals besides the horse. D.P.G.

290. Milk Sickness: A Retrospect. Anonymous. Jour. Amer. Med. Assn., *128*, No. 10: 734. July 7, 1945.

The history of milk sickness throughout the Middle West is reviewed, beginning with the death of Nancy Hanks Lincoln in 1819 in southern Indiana. Tribute is paid to the paper by Philip D. Jordan, Miami University, Oxford, Ohio; Milk Sickness in Kentucky and the Western Country, Filson Club Historical Quarterly *19:* 21, Jan., 1945. As late as 1937–38, 21 cases occurred in Illinois, with a mortality rate of 10 per cent. The editor states that "The problem of the eitology seems simple, but the careful investigator knows that it only seems so. . . . The 'trembles' presents a mutable picture not uncommon to many intestinal infections or endemic troubles where in earlier days calomel, bleeding or opium was indicated by symptoms. Finally, many poisons show such a variation of the clinical picture that the presence of an unknown substance would confuse even the most experienced practitioner. But as *Eupatorium ageratoides* still grows in our soil, and as the rayless goldenrod of the Southwest also contains tremetol and caused the trembles, milk sickness may well remain in the textbooks." D.P.G.

291. Bacteriological Study of Canned Evaporated Milk Implicated in an Outbreak of Gastroenteritis. A. G. Osler, E. Dillon, and L. Buchbinder, Bur. of Labs., N. Y. C. Dept. of Health. Jour. Bact., *49*, No. 4: 413. April, 1945. Proc. of Local Branches.

Forty-three cans of evaporated milk were implicated in an outbreak of acute food poisoning. Of these, 24 gave bacterial counts greater than 100

per ml. although 12 showed no apparent abnormality; 14 gave counts greater than 1,000, 5 were normal in appearance; 9 gave counts greater than 1 million of which 2 appeared normal. Abnormal-appearing cans showed leakage, swelling, or rusting, with accompanying changes in appearance and odor of the milk.

Streptococcus faecalis was present in greatest number and in most of the cans, occurring in pure culture in some. The characteristics of 49 strains of this microorganism are described. Particularly noteworthy is the fact that it was not completely destroyed by exposure to 60° C. for thirty minutes. The "occasional presence" of *S. faecalis* in pasteurized milk makes this finding of interest. The question is raised of its possible etiology in food poisoning of "unknown" origin. D.P.G.

HERD MANAGEMENT

292. A Leak in Dairy Farm Profits. R. R. GRAVES, Bur. Dairy Indus., U.S.D.A. Milk Dealer, *34*, No. 6: 68–72. March, 1945.

The annual loss of nitrogen per cow per year through not making provision for saving the urine voided by 27,000,000 dairy cows would amount to 621,000 tons of nitrogen, a loss exceeding the total amount of nitrogen consumed yearly in commercial fertilizers. Since this loss occurs in ordinary methods of handling manure from the dairy barn, provision should be made to conserve and utilize this source of liquid manure in order to make available this valuable source of ntirogen for the soil and to stimulate the growth of grass and other crops.

Results of experiments to determine loss by ordinary handling methods together with methods of conserving are cited. The average nitrogen content is 1% and on basis of average amount of urine from cows used in experiment the annual loss per each 1,000-pound cow would be approximately $3.00 based on prevailing commercial fertilizer prices. Directions for handling manure through drainage into a cistern from the gutter drain of urine are given. It is especially important to save and utilize all natural forms of nitrogenous fertilizers at all times and particularly now because of wartime demands for commercial nitrogen for other purposes. C.S.T.

ICE CREAM

293. Honey in Ice Cream. P. S. LUCAS, Dairy Dept., Mich. State Col., Mich. Agr. Expt. Sta., Quarterly Bul., 27: 4. 1945.

Honey, calculated to be 70 per cent as sweet as cane sugar, was used in ice cream mixes to replace some of the sugar. The honey tested 81.56 total solids. Light- and amber-colored honey were found to be superior to the dark honey. When 30 per cent of the cane sugar was replaced by light-

colored honey, it was possible to make vanilla with no unfavorable comments. The same was true with chocolate and other flavors. A substitution of 10 per cent of the sugar did, however, cause a slightly noticeable but not objectionable taste.

Honey ice cream can be made by using honey as a sole sweetener at a cost of four cents per gallon more than vanilla ice cream.

This bulletin also lists five mixes containing honey in different proportions. C.D.D.

MILK

294. Sales Manpower for Milk Companies. C. W. Esmond, G. P. Gundlock & Co., Cincinnati, Ohio. Milk Dealer, *34*, No. 3: 44–46. Dec., 1944.

Due to existing manpower shortages many milk companies are operating with reduced or skeleton sales departments. The sales force must be kept in order to meet post-war demands and not merely take orders for dairy products. The dairy industry is stable and therefore offers inducements to men interested in obtaining an assured career for the future even under existing war-time manpower shortages. The re-employment of ex-service men experienced in salesmanship would be utilized, new blood if possible should be hired and every effort made to build up the sales department now in order to be equipped to expand and promote the sale of all dairy products when such products are again available. Both wholesale and retail sales promotion both now and post-war are essential to the success of all milk plants if the "American Way" of producing more and giving more and better employment to all is to be maintained. C.S.T.

295. Cleaning and Sterilizing Operations in the Dairy. C. M. Moore, Dir. of Res., The Diversey Corp., Chicago, Ill. Milk Dealer, *34*, No. 4: 38–44, 88–90. Jan., 1945.

From a sanitary standpoint milk and dairy products are no better than the utensils and equipment with which they come in contact. Routine cleaning is a dairy "chore" and therefore not always given the proper attention, yet no other plant operation pays greater dividends in quality from the farm through to the consumer. The author stressed the need of a planned program to impress plant personnel with importance of absolute cleanliness to prevent disease or even epidemics; that disinfectants to be effective must be used only on clean equipment; that hot water must be hot and steam used under pressure and that exposed metallic surfaces cause flavor defects. Milkstone removal without injury to metallic surfaces is vital, therefore proper cleaning without removal of tin should be demonstrated. Directions for proper removal of milkstone through selection of right brushes, alkalies,

acid and rinsing are given. Typewritten instructions for proper cleaning of every major piece of equipment are recommended. Cleaning and disinfecting are separate and distinct operations and must be modified for different pieces of equipment such as glass-lined tanks, bottle and can washers and for floors, walls, windows and storage rooms. "It is good business to operate the most sanitary dairy in your town, city, county or state." C.S.T.

296. Reciprocal Relations Between Producer and Distributor of Milk. A. D. BURKE, Dairy Dept., Polytechnic Inst. Milk Dealer, *34*, No. 2: 96–100. Nov., 1944.

Despite apparent divergent views and objectives of producers and distributors of milk they both have mutual and common major objectives if future success and growth is to be attained. "One is as essential to the other as the miner of ore is to the fabricator of steel." The author lists these mutual objectives as: (1) "To promote the ultimate consumption of more and better dairy products" combined with a unity of purpose against competition of dairy products with substitute products or with other food products; (2) "maintenance of minimum cost" in both the uniform production and distribution of milk and in manufactured dairy products; (3) united action in protecting the industry against unfavorable Federal and State legislation and to sponsor favorable regulations and (4) cooperative merchandising effort in establishing quality, consumer good will and confidence and in forming a joint association. C.S.T.

297. Food Values Under the Cream Layer of a Quart of Milk. PROF. L. M. DORSEY, Dept. of Dairy Husb., Univ. of Maine, Orono, Maine. Milk Dealer, *34*, No. 6: 49–50. March, 1945.

Milk in the light of modern nutritional knowledge is an all-purpose food. It also possesses high therapeutic properties in its fractional components. A table showing percentages of nutritive factors in a quart of whole milk and in a quart of milk from which the cream has been removed graphically shows the food value of "skimmed milk" in relation to daily adult nutritive needs. The energy value and fat soluble vitamin content of "under" milk is still high and mineral and protein content and water-soluble vitamin content is only slightly different than in the whole milk. Milk under the cream layer is therefore still a highly nutritious food product suitable for adult utilization and consumption and should be used to a greater extent to supply nutritional essential dietary elements. C.S.T.

298. What About Post-War Deliveries? EDWARD THOM, Assoc. Editor, Milk Dealer, *34*, No. 7: 82–96. April, 1945.

In a summation of a nation-wide survey covering 38 states by questionaire wherein seven specific questions pertaining to war-time economies in

milk deliveries were asked, comprehensive percentage figures together with sample replies received, are tabulated and cited by the author. In general, the results of this survey show that most of these economies were desirable and should be retained. Specifically, there were dissenting opinions on all questions. Eighty-four per cent of all dealers responding were in favor of retaining every-other-day delivery but only 32.7% deemed it possible without mandatory legislation. Fifty-five and eight-tenth per cent of replies through labor unions reaction to post-war every-other-day delivery would be favorable since 81.6% replied that drivers were earning more money. Ninety-three per cent favored daylight delivery of milk and 58% favored bottle deposits on all bottles used. Fifty-seven per cent favored the curtailment of special deliveries of milk although many questioned whether it could be attained on a voluntary basis. Many variations in replies are cited from all sections of the country. C.S.T.

299. Uses of Compressed Air in Dairy Plants. ANONYMOUS. Milk Dealer, *34*, No. 2: 36–37, 62. Nov., 1944.

The author sites the use of compressed air in The Telling-Belle Vernon Co., Cleveland, Ohio, in various plant operations and expresses view that compressed air should have even more uses in any dairy plant in cutting maintenance costs and in increasing operating efficiency. Its use for pressure rinsing in bottle washer, on high-temperature–short-time pasteurizer valves, on case conveyer lines as an air brake, for reclaiming rubber filler valve seals with air pressure pneumatic grinder, as a portable compressor for drilling and repair work and for a paint sprayer and in dairy grease pumps, tires, etc., are all described. C.S.T.

300. High-Temperature–Short-Time Pasteurization. W. L. FILBERT, Dairy Supervisor, Atlanta Branch, York Corp. Milk Dealer, *34*, No. 7: 76–80. April, 1945.

The history of this newer approved method of pasteurizing milk is briefly reviewed and a discussion of plate heat exchangers as contributing to the rapid adoption by milk plants of this method. The safety features of automatic control of water and steam and of flow diversion is described and the author cites 15 features of this method in summarizing and comparing with the older holding method of pasteurization. C.S.T.

301. Factors Affecting Can Washing. V. SCHWARZKOPF, Lathrop-Paulson Co., Chicago, Ill. Milk Dealer, *34*, No. 7: 50–52. April, 1945.

A major factor affecting quality control of dairy products is the condition of the cans in which milk is handled. The author cites 5 factors essential to obtain clean, dry, commercial sterile cans to insure high quality.

(1) Adequate steam supply of uniform pressure obtained by providing controlled pressure; (2) uniformity of water supply and constant pressure; (3) maintenance of proper temperatures for washing, rinsing, sterilizing and drying—recommended temperatures are cited; (4) proper water treatment to prevent scale formation, to change water in machine and use of acid and alkali cleansers in water used and (5) proper care and attention of the machine by careful check, repair and corrosion prevention and control.

C.S.T.

MISCELLANEOUS

302. Magnesium as a Possible Post-War Metal in the Dairy Industry. ANONYMOUS. Milk Dealer, *34*, No. 3: 76–77. Dec., 1944.

With magnesium having but 23% of the weight of iron and 64% that of aluminum, its lightness is its most striking quality. As an alloy with other metals it is adaptable to modern processes of fabrication in many forms, is readily machinable and weldable, has high scrap value for remelting, has low conductivity, is non-magnetic and non-toxic and as a result of war demands is readily available. In castings, wheels, in trucks, tanks and for building parts used above the floor line magnesium may be of value in many dairy plants of the future. C.S.T.

303. Present and Future Employee Relations. PAUL POTTER, Exec. Secy. Assoc. Milk Dealers, Chicago, and Indus. Member, Appeal Committee, Natl. War Labor Bd., Washington, D. C. Milk Dealer *34*, No. 3: 60–62. Dec., 1944.

Manufacturers of dairy products selling a commodity plus a service wherein labor union competition for unionization of dairy plant employees exists and where the necessity of knowing processes of labor negotiations, personnel relations and methods of settling disputes are essential to both present and post-war business operations, should be familiar with all such problems as well as with the various Federal agencies with which they will have to deal. Government regulation of industrial relationship is as inevitable for post-war operation as for war-time economy. The milk industry therefore must carefully study all factors involved and must exchange information with other milk dealers in other cities in order to work out a standardized procedure. Every wage or contract dispute is subject to a review by a national or regional director of a Wage and Hour Division of the U. S. Dept. of Labor and possibly to other Federal agencies. The author lists 8 steps that either or both the employer or employees may take under present day Government controls in order to settle or arbitrate disputes, contracts, or grievances whereby both sides may name spokesmen, arrange for collective bargaining, for conciliations, for hearings, for presentations

of briefs, for naming of an arbitrator or for appeal. Knowledge of these procedures are as important to the milk dealer for successful operation as to know the problems of procurement, processing and merchandising.

C.S.T.

304. For Your Post-War Construction Program, Investigate Glass. ELMER LUNDBERG, A.I.A., Pittsburgh Plate Glass Co., Pittsburgh, Pa. Milk Dealer, *34*, No. 3: Dec., 1944.

Ample light and cleanliness in the construction and remodeling of plants to facilitate the sale of dairy products is "smart" business. In addition long wearing qualities, insulating properties and diffusion of sunlight are properties possessed by glass when used as building material for dairy industry from the farm to the milk plant. Glass building blocks of various sizes for buildings, Carrara structural glass for walls and foamglass for insulating material are the three forms of glass said to be suitable for dairy plants. Sanitation, condensation, controlled humidity, insulation, easy maintenance and permanence are said to be advantages of glass for building construction.

C.S.T.

305. How to Get Best Results from Synthetic Tires and Tubes. J. E. POWERS, Truck and Bus Tire Dept., The B. F. Goodrich Co., Milk Dealer *34*, No. 6: 84–86. March, 1945.

With tires classified as the most critical of all war items and with synthetic rubber the only rubber now available, the need for careful use and the practice of conservation operation are now of utmost importance. Synthetic rubber is a substitute material and trucks operating on tires and tubes made must be operated on basis of conserving tire strength and wear. "Load," "speed" and "inflation" are main factors to control for best service. Heat is rubber's worst enemy, therefore less speed or less load or less under deflation must be control factors to watch. The author lists 8 important factors which affect truck tire life. Special care should also be given to synethetic inner tubes and flaps. To prolong tire life will pay dividends now and in the future as well as "definitely contribute to the war effort."

C.S.T.

306. New Development in Paint. ANONYMOUS. Milk Dealer, *34*, No. 6: 64–65. March, 1945.

As a result of war-time development in research on paints for use on all surfaces and which will be available for post-war civilian use should make all paints more valuable for coating and protecting all painted surfaces. Exterior emulsion paints composed of new oils and binders of the synthetic type and new pigments which are less porous will prevent old-time chalking

and delay disintegration of the film as well as alkali and chemical resistance properties to both exterior and interior surfaces of wood, concrete or metal. Special fire-retarding, chemical-resistant, fume-proof, insecticidal and non-slip paints will also be available. C.S.T.

307. Cutting Fuel Costs. R. F. STILWELL. Milk Dealer, *34*, No. 4: 104–107. Jan. 1945.

Based on 20 years experience the author states that coal consumption in the average plant is 5 to 10% higher than the equipment would warrant. To prevent losses and reduce coal consumption it is a patriotic duty to follow the coal used from the car on the track to the heat units in the stack. Suggested general changes that may conserve coal are given such as change stoker feed rate, ram adjustment, fan-air pressure and damper position. Fires should be cleaned more frequently with lower grade, war-time coal as should the boiler and stoker. Repairs on all parts should be made quickly and possible relocation of burner stoker, soot blowers, etc., made. Specific suggestions for saving coal are : (1) complete unloading of cars; (2) avoid segregation of coarse and fine coal; (3) store carefully to avoid storage fires. Repairs of all boiler parts, grates, dump plates, brickwork and tubes with repeated checks are essential. Stack losses through low combustion and imcomplete burning of gas should be checked and corrected, ash and clinker, soot and scale removal should be complete. Excessive smoke should be avoided. The use of exhaust steam to heat boiler feed water and buildings will reduce coal consumption. Insulate all steam pipes and check all steam losses. Saving a small fraction of coal consumption in every plant means saving many millions of tons a year on a national scale. C.S.T.

"Unmentionables? NO! NO!

To your grandmother, maybe yes. But this generation, and all future ones I hope, is tired of being told only half a story. They wish to know more and more of other peoples, other ideas, better ways of living."

"Sí, sí, maestro Miguel. And what goes into the making of fine foods like *ice cream* must also be an open book for all to read and know."

"You are very smart horse, Plato. Always I say so."

"Once upon a time, it is not proper to mention the milk solids in ice cream. People might think it is to cheapen the product. But now we know that they give nourishment *and* a pleasing texture. It has been so these many years, but hidden under the blanket of so much talk about the butterfat."

"But definitely. And the same with the vanillin which we use to enhance the fine vanilla flavor. Vanillin is not an unmentionable today—it is something interesting to talk about. How it is derived from tropical spices for use in Michael's Mixevan. How Nature and Science combine in making the *controlled flavor* in that favorite of all frozen foods—vanilla ice cream."

"Bravo! When these dairymen advertise their ice creams, they will not hesitate to mention *vanillin*. We salute them, no? Más vale tarde que nunca . . . better late than never."

Mixevan—"America's Flavorite" and other powdered vanilla products

DAVID MICHAEL & CO.

half a century in the flavoring field

Front and Master Streets, Philadelphia 22, Pa.

Your advertisement is being read in every State and in 25 Foreign Countries

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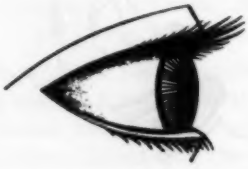

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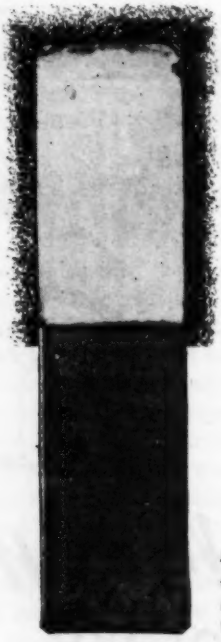

Milkstone deposit

Milkstone deposit removed by Wyandotte S.R.-10

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Baked-on milk solids disappear like magic from heat exchangers and flash pasteurizers when you clean them with a solution of Wyandotte S.R.-10.

Clean away even the most stubborn milkstone deposits — *quickly* and *thoroughly* — with S.R.-10. Complete the cleaning operation with a Wyandotte G.L.X. solution. Although it's a powerful cleaner, Wyandotte S.R.-10 is *safe* to use and it produces no unpleasant fumes.

Use Wyandotte S.R.-10 occasionally for can washing, too. It quickly banishes accumulated film from cans, leaving them shiny and bright, and helps keep the can-washing machine clean.

Let your Wyandotte Representative tell you more about milkstone control with easy-to-use S.R.-10. He's a good man to consult, too, about cleaning all over your plant.

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SERVICE REPRESENTATIVES IN 68 CITIES

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Purity Protected
to the last drop

A Seal-Kap's perfect closure on clear glass bottles assures the utmost health protection. And Seal-Kap protection is continuous from the moment it caps the bottle right through to the time the last drop is used.

First, during handling and delivery, no dangerous impurities can touch the pouring lip because Seal-Kaps completely shield this vital area. Later, in the home, Seal-Kaps prevent wasteful, messy fork-prying because Seal-Kaps come off with only a quick, easy twist of the wrist. And tough, durable Seal-Kaps go back on again, as often as necessary with a tight-fitting snap, to prevent spilling and food contamination.

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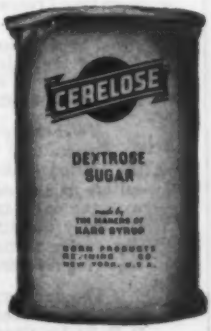
that many people make mistakes in the meaning of words? Here are five old words and one new word. How many people, do you think, know what these words mean?

How many out of 10?
Write your guess—then turn the page upside down for the answer. (Based on Johnson O'Connor's book "English Vocabulary Builder.")

DEMOCRACY	a ☐
SLEEK	b ☐
NATTY	c ☐
COY	d ☐
VIRILE	e ☐
DEXTROSE	f ☐

Educational advertising has taught 8 out of 10 people that dextrose is the *new* word for food-energy sugar.

ANSWERS
a — 8
b — 2
c — 5
d — 7
e — 9
f — 4



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CERELOSE is dextrose

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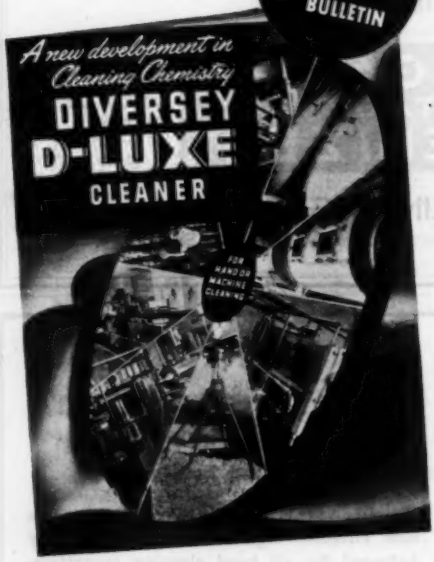

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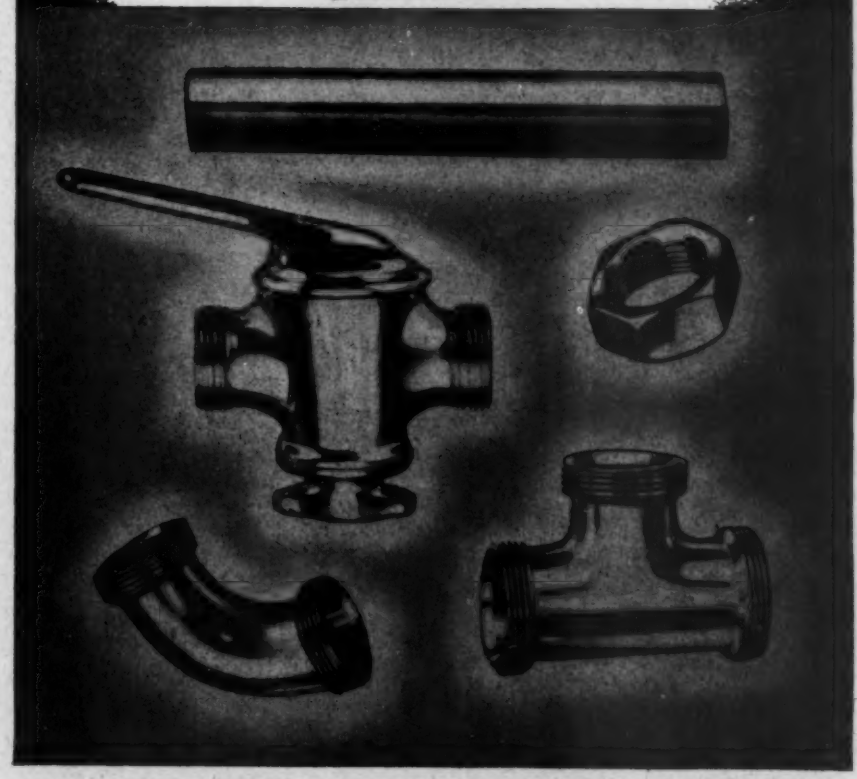

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